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# 41ST ANNUAL CONFERENCE REPORT ON COTTON INSECT RESEARCH AND CONTROL

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## Foreword

There were 10 million acres of cotton harvested in 1987 with an average yield of 1.5 bales/acre (Table 1). This amounted to 14.7 million bales of cotton being produced by USA growers. These figures reflect an increase of 644 thousand harvested acres compared to 1986, but, more importantly, average yield per acre was increased by 0.4 bale. Consequently, 4.9 million more bales of cotton were produced in 1987 than in 1986. The leading cotton-producing states were Texas, California, and Mississippi.

Arthropod pests reduced yield by 5.9% in spite of the best control measures (see tables 2a to 2ee). This amounted to a loss of 856 thousand bales from potential yield costing an estimated $246.5 million in revenue. The beltwide cost per acre for controlling arthropod pests was $31.89, which reflected an increase of $7.19/acre over 1986. The total cost for controlling insects (Table 2a) was $316 million. The estimated total cost of arthropod pests to USA cotton production was $562.5 million.

Increased insecticide control costs per treated acre may be attributed to increased severity of the boll weevil, *Anthonomus grandis* Boheman, and consequent increased number of applications required (42% greater) and cost per application (17% greater). The cost per application for *Heliothis* (bollworm/tobacco budworm) increased (12%) as well, and this probably reflected the expanded use of mixtures to control this pest. Boll weevils caused more damage in 1987 in spite of control measures than

did Heliothis, but the total dollar cost was greater ($215 vs 189 million) for Heliothis because of the greater cost per application. Lygus bugs were less important as pests in 1987, but they were probably controlled incidental to the foliar-applied treatments for weevils during early season as well as by the widespread usage of aldicarb, in-furrow, at planting. Other pests cited as significant included aphids (beltwide) and stinkbugs in the Carolinas.

Resistance to pyrethroids in the tobacco budworm (TBW) Heliothis virescens (F.), was recorded in Texas, Arkansas, Louisiana, Mississippi, and Alabama, but not in the Carolinas, Georgia, and western states. TBW populations were relatively high in June but declined precipitously thereafter. A pyrethroid-resistance management program was successfully implemented and near complete compliance was noted in the use of materials other than pyrethroids for controlling first generation Heliothis in cotton.

## Crop and Arthropod Pest Conditions

Alabama. A lack of moisture delayed seed germination and seedling emergence for about 1/3 of the state's cotton crop. Prospects for high yield improved by mid-July, but the heat and drought stress which followed reduced the yield potential. Thrips populations were lower than in the previous six years. The soybean thrips, Sericothrips variabilis (Beach), reappeared as the predominant species. Low numbers of variegated cutworms, Peridroma saucia (Hubner), were observed over an extremely wide area. However, little damage was observed.

An atypical mid-May bollworm (BW), Heliothis zea (Boddie), flight occurred in a little over one half of the crop. Eggs were often present on 30 to 50% of the terminals. Natural enemy numbers were low and there were few squares on the plants. Consequently, where insecticide treatments were not made for these populations, terminal damage occurred. The June TBW population densities were high, and the duration of occurrence was long. Two to three pyrethroid applications were often necessary to control these populations. The BW occurred about one week earlier than usual in July, and the TBW occurred within five to ten days afterward. The TBW was the predominant species for the remainder of the season. Pressure remained heavy in portions of North Alabama, but late season numbers were quite low for the remainder of the state. The pyrethroids did not provide satisfactory control of these populations.

Boll weevil populations were extremely high statewide and most producers made two to three applications for emerging overwintered weevils. Control efforts were complicated by an extended period of emergence by the overwintered weevil in North Alabama. Due to widespread early stalk destruction and use of Dropp®, 1987's fall weevil population was less than in 1986.

The cotton aphid, Aphis gossypii (Glover), was a widespread problem by early July and remained a chronic problem through harvest. Several applications of the most efficient organophosphate insecticides were usually necessary for control of this pest. The western flower thrips, Frankliniella occidentalis (Pergande), is established as a pest of cotton statewide. The "freezing" of young bolls seemed to be associated with this pest. Specifically, a disease-appearing lesion beginning at the junction of the peduncle base and stem is symptomatic of this damage and certain varietes had more damage than others. For the second year in a row, beet armyworms (Spodoptera exigua (Hubner), often in association with soybean loopers, Pseudoplusia includens (Walker), and cabbage loopers (Trichoplusia ni (Hubner), defoliated a large amount of cotton statewide. Though generally occurring at subthreshold levels, whitefly populations were higher than normal and widespread.

California. The cotton aphid was the major insect problem in 1987. This pest was widespread and high populations occurred in most of the San Joaquin Valley counties. The pest appeared in mid-April in the east side of Tulare County and the population occurrence moved westward. Chemical applications for control of aphid populations in June were ineffective, but improved control was noted in July. Eventual control was accomplished by natural enemies, most notably Lysiphlebus. A request for a Section 18 for Capture® (FMC) was not approved by the California Department of Agriculture. Lygus populations were low except near point sources such as weedy fields and orchards. One insecticide application generally took care of the problem. Mite populations were low early season but increased to economic levels during mid-season.

Georgia. The 1987 growing season was less than ideal but better than in 1986. Winter rains were greater than normal, but there was little rainfall during planting. Consequently, most plantings were delayed because of dry weather, and much of the crop was seeded in early to mid-May. Later, as prices

increased, more acreage was planted to cotton in June and even early July. The summer months were generally drier than normal. Scattered showers favored good fruit set in some fields, but much of the dryland cotton suffered. Irrigation helped considerably, but in many cases, was not sufficient to fully supplement the reduced rainfall. High temperatures during much of the season compounded moisture stress. Late August rains caused some "tightlock" and secondary growth. Many dryland fields ready for defoliation and harvest in September had regrowth problems. By mid-September, the weather was again dry. Grades, staple length and strength were better than average.

The mild winter of 1986-87 assured insect problems. Trap captures of overwintered boll weevils were extremely high. Thrips were widely distributed, but populations were lower than in recent seasons. Later planted cotton escaped the movement of thrips from early hosts. Cutworms were commonly reported in seedling cotton with a number of fields requiring treatment. Grasshoppers and snowy tree crickets, *Oecanthus fultoni* (Walker), were abundant early in cotton fields, but foliage feeding probably did not affect yield.

The most significant insect event of the 1987 season was the early June TBW moth flight. High egg counts occurred in many fields and larvae infested terminals of early squaring plants. Many infestations were not treated; but, even where controls were applied, loss of apical dominance occurred in a high percentage of plants. Delayed planting and a late spring allowed many fields to escape severe boll weevil problems. Hot, dry conditions in June further suppressed weevil populations after they were treated during the pinhead square stage. Tarnished plant bugs, *Lygus lineolaris* (Palisot de Beauvois), and cotton fleahoppers, *Pseudatomoscelis seriatus* (Reuter), were abundant. Early sprays for the TBW and boll weevils suppressed plant bug populations, but many fields required additional treatment. The less conspicuous fleahoppers were probably more damaging than the tarnished plant bug.

*Heliothis* activity in July and August was erratic. TBW and BW infestations varied from field to field. Generally, infestations were below normal. Boll weevil populations rebounded in August as the second field generation emerged and by early September, the weevil was the main insect pest. Insecticide treatments as part of the USDA-APHIS Boll Weevil Eradication Program helped to reduce populations, but failed to adequately protect top bolls. Beet armyworms were pests again in 1987. Fortunately, they were not as bad as in 1986. Some fall armyworms, *S. frugiperda* (J. E. Smith), were detected, but infestations levels were very low. Treatments were required in some fields for control of the soybean looper. Western flower thrips was reported in several counties and spider mites were more numerous than in recent seasons, although few fields required treatment. Whiteflies reached treatable levels in isolated areas for the first time in many seasons. Aphids have emerged as a major pest since 1980, and they were most severe in 1986. Fields were often sprayed specifically for this pest.

Louisiana. Growers planted about 620,000 acres of cotton. In general, insect control was adequate, growing season weather was good, and harvest conditions were excellent. The level of early season insects (i.e., thrips and plant bugs) was about average for Louisiana. Approximately half of the state's acreage is treated at planting with in-furrow pesticides which usually provide excellent thrips control and some suppression of plant bugs. Plant bug populations were relatively low; nevertheless, the potential of this pest was not realized because so much of the acreage was treated for boll weevil during early squaring.

The boll weevil was a major pest during 1987 and probably accounted for at least half of the total insecticide applications. Pheromone trap catches were high throughout the state and overwintered weevil populations were high at the onset of squaring. Most growers utilized some form of early season weevil control; some treated known "hotspots", some made one or more pinhead square applications, and others added methyl parathion to their chlordimeform yield enhancement program. Early season treatment was effective in reducing the weevil population, but it did not eliminate the pest for the remainder of the season. In most fields, boll weevils required treatment again by late July, and subsequent applications were needed, especially during periods of high emergence, until the crop was defoliated.

Low aphid populations were present in most fields during July, but the number of fields treated was less than in 1986. Moreover, aphid control was apparently more effective than last year because few of the fields required more than one application. Spider mites, cabbage loopers, and whitefly populations were present, but they generally did not attain pest status.

Heliothis populations were low except in June when high numbers of TBW were present. Control was adequate season long, and the few exceptions could be attributed to factors other than resistance. Compliance with the TBW resistance management program was perhaps as high as 95%. In most cases, TBW control in June was achieved with phosphate or carbamate materials, while the use of pyrethroids was postponed until July. The resistance monitoring program indicated that the percent of resistant genotypes in the TBW population was lower than in 1986 and did not increase from June through September.

Mississippi. The crop year was characterized by a good planting season with adequate moisture early, limited moisture mid to late season, and an ideal harvest season of a relatively high yield, high quality crop. The most serious insect problems were boll weevils and TBW. Other problems included western flower thrips, aphids, and to a degree, early season plant bugs, thrips on seedling cotton, cabbage loopers, whiteflies and spider mites.

In late May and early June, TBW populations were very high. It was anticipated that populations of this pest would be serious in July but this did not develop. There were failures in control as early as the first half of June. Other failures were encountered sporadically season long. In a few cases, resistance was associated with the pyrethroid failures. In other cases, resistance could not be documented. Pyrethroid resistance monitoring of TBW male adults using the residual film in vial (Plapp technique) indicated relatively high levels of resistance in the western delta to almost no resistance in populations in east Mississippi.
Boll weevil populations were higher than they had been in 15-20 years. Damaging populations were reported from all cotton growing counties. Some producers made 12-15 applications to control boll weevils.

Missouri. The 1987 growing season was close to ideal. Adequate winter rainfall, followed by good planting weather, accounted for a total of 189,000 acres from the original planting of 190,000 acres. Five inches of rain in June, 5.25 inches in July and 2 inches in early August provided adequate moisture. Harvesting conditions were ideal, and they contributed to the quality and quantity of this crop. Thrips (*Frankliniella fusca* (Hinds), *F. tritici* (Fitch), and *Sericothrip variabilis*), injury was observed in a few fields, especially where in-furrow granular insecticides or over-the-top preventative insecticide applications were not applied. Thrips injury was minimal because weather conditions allowed the crop to maintain maximum growth. Cotton aphid populations were light but continued to persist throughout the season in some fields. Few fields reached economic thresholds. Spider mite (*Tetranychus* sp.) populations were present throughout the season, however, only spot treatment was required.

The tarnished plant bug, cotton fleahopper, and clouded plant bug (*Neurocolpus nubilis* [Say]) make up the plant bug complex in Missouri. Populations of tarnished plant bugs and cotton fleahoppers were a season long problem and approximately one-third of the acreage received insecticide applications. Many fields received three or more applications of insecticide. Clouded plant bugs were present in many fields, however, damage was minimal to small bolls because of the early maturing crop.

The *Heliothis* complex caused problems throughout mid and late season. All fields had worms present, however, only one-third of the acreage reached economic thresholds. A few fields required more than two applications of insecticide. The boll weevil caused a few fields to be treated by late June. This pest could be found in every field by late August, but by this time the crop was so near maturity that little damage was caused.

North Carolina. Moisture conditions, although varying greatly throughout North Carolina, were generally dry. Consequently, yield prospects were depressed to approximately one bale per acre. Overall insect pressure was very light, especially for the "big two", the European corn borer, *Ostrinia nubilalis* (Hubner) and the BW. Damaged-boll surveys (184 randomly selected fields; 12 fields in each of the 16 largest cotton-growing counties) estimated BW and European corn borer damage at 1 and 1.5%, respectively. The aformentioned BW damage is perhaps the lightest in the last decade. A combination of light insect pressure

and the widespread use of a new egg threshold (10% eggs) likely accounted for the low damage. Green stinkbugs caused approximately 2.5% boll damage, probably representing an average year for this species. Interestingly, the few survey fields which were unsprayed suffered average boll damage of 26%, 11%, and 8% from green stink bugs, BW, and European corn borers, respectively. This is in keeping with previous observations of moderate to complete yield loss in unsprayed fields, with or without the presence of boll weevil.

Thrips population levels were high. However, most producers used aldicarb in-furrow, at planting, and moisture conditions were adequate for activation. Tarnished plant bugs and cotton fleahoppers were observed, but they occurred at levels representing approximately 1/5 to 1/20 of what other states regard as threshold levels. Aphids, however, particularly with the reduced usage of organophosphate insecticides for BW and boll weevil diapause control, have become more of a late season problem, especially on cotton regrowth.

Oklahoma. Extreme drought, followed by three weeks of rain, delayed planting, and caused the crop to be three weeks behind schedule. Nevertheless, timely rains later and a favorable September helped to produce the best crop since 1979. The mild winter of 1986/87 ensured high survival of overwintering boll weevils. A total of 28 weevil traps were placed adjacent to over-wintering sites in Jackson, Tillman, and Kiowa counties. The average number of weevils captured per trap during 1987 was 17.1 compared to 2.3 in 1986. By August, boll weevils were numerous in fields across southwest Oklahoma. Fields were sprayed up to six times. The number of fields treated for cotton fleahoppers and a moderate population of *Heliothis* spp. across southwest Oklahoma resulted in the majority of the irrigated fields being sprayed three times. *Heliothis* spp. pheromone traps were run at Altus, Jackson County from April 1st to September 10th. The first BW moth was caught on April 1st. Peak catches occurred on June 27th, July 6th, August 31st, and September 9th. The first TBW moth was caught on April 30th. Peak catches occurred on June 27th, July 2nd, August 31st, and September 7th. Two spotted spider mites (*Tetranychus urticae* Koch) populations reached damaging levels in a few fields in early September.

South Carolina. Over 120,000 acres of cotton were planted. For the second year in a row, yields were reduced by a moisture shortage in June and July. Yields were in the range of 150 to 300 lb lint/acre in the most drought-stressed areas.

There were more reports of boll weevil reproduction in the Eradication Zone of South Carolina than in 1986. By the end of the growing season, there were 50 to 60 fields where reproduction probably occurred. This increased activity may have stemmed from movement of boll weevils from Georgia and the Buffer Zone of South Carolina. Also, problems with a computer-generated mapping system resulted in delays in trapping new fields. Problem fields in the 1987 Eradication Zone will be trapped at an increased rate in the spring of 1988. The South Carolina Grower Foundation and the Clemson University Technical Advisory Committee will work with USDA-APHIS to ensure that weevils are contained and eliminated. Weevil migration from Georgia should no longer be a serious problem in 1988, as that state will also be involved in the Eradication Program. The Buffer Zone of South Carolina will become an Eradication Zone and the new Buffer Zone will be established in Alabama.

The Heliothis spp. situation was a reversal of that observed in 1986. This year, a high percentage of fields were sprayed two or three times in June and July to control BW/TBW, but pressure was light for the remainder of the season. There were exceptions, but, in general, infestations were unusually low from mid-July through August. Thrips populations were moderate. With the drought, it appeared that there was little advantage in controlling thrips this year, since early maturity generally resulted in lower yields. Aphids were a problem for many growers in July and August. For the third year in a row, stink bugs caused economic problems. The worst damaged area appeared to be in the southern part of the state, but there also was some economic damage in major cotton-producing counties.

Texas. The crop was generally planted two to three weeks late across most of the state; delay was due to wet, cold weather. A late freeze in March further delayed plant development in Central, South, and East Texas. Despite setbacks, favorable temperature and moisture conditions prevailed throughout the remainder of the season. Excellent temperature for fiber maturation was experienced during October in the High Plains, Rolling Plains, and West Texas. This accounted, in part, for high yields in these areas.

The boll weevil was a more serious economic problem than since 1978, and it caused damage throughout its range. Control of overwintering populations with insecticide, the use of short-season cotton varieties, and delayed, uniform planting in the Rolling Plains were the primary IPM tactics used to manage the boll weevil. Senate Bill 1189 formed the legal basis to enforce penalties for failure to destroy stalks after harvest as a cultural means to reduce overwintering boll weevil populations. This law, termed the "Boll Weevil Law", allows for the establishment of pest control districts under which the boll weevil can be managed on a community wide basis through stalk destruction and other means. This law will go into effect in the 1988 season.

Cotton fleahopper damage ranged from moderate to severe in south and central Texas. Over the last two years the cotton fleahopper has increased in damaging numbers in the Rolling Plains, High Plains, and West Texas. As a result, sampling for cotton fleahopper has intensified through Extension Service IPM programs and by private consultants. Insecticide applications were recommended in these areas for control of cotton fleahopper, where traditionally this pest has not been a major problem.

A statewide monitoring program for pyrethroid resistance in the TBW was again conducted in 1987. Resistance was widespread throughout South, Central, and West Texas. Levels of resistance were lower in 1987 than in 1986. This was attributed to the TBW resistance management program that was put in place in 1987. Most control failures were observed in extremely late-planted cotton. For the most part, TBW resistance was managed by not using pyrethroid insecticides in pre-blooming cotton, synergizing pyrethroids with chlordimeform, and switching to other classes of insecticide late in the season if control was lost using pyrethroids, Again, fields which encountered the least problems were those planted as early as possible with a short-season variety.

In summary, the 1987 cotton season in Texas encountered moderate-to-severe insect problems. Despite this situation, Texas set record yields. Insects were successfully managed through pest management programs. The major variables for yield in Texas are adequate moisture and favorable temperatures at the appropriate time during the season. Texas cotton enjoyed both of these positive factors during optimum periods of plant growth and fiber development.

Tennessee. Thrips injury was observed in a few fields, especially where preventive granular insecticides or overtop curative insecticide applications were not made. Thrips injury was the lightest in six years. Boll weevil control was needed by mid-June in many fields. Tarnished plant bug populations were low. By late June, BW/TBW eggs and larvae were more numerous than usual. Green stink bugs and grasshoppers were also observed. Coincidental with pest insects were greater-than-normal populations of natural enemies, particularly the spotted lady beetle, Coleomegilla maculata, and the big eyed bag, Georcoris sp..

Spring boll weevil pheromone trap catches indicated that the vast majority of overwintered weevils were located along the southern tier of counties of West Tennessee. These included Shelby, Fayette, Hardeman, McNairy, and Hardin Counties. Relatively few boll weevils were captured north of these counties.

BW/TBW infestations continued to plague cotton through July. BW egg-laying and larval occurrence intensified in late July and early August. At the same time, boll weevil adults dispersed north from the southern tier of counties. BW moths, eggs, and larvae continued to be a problem through August. Larvae were found in cotton into September. Stink bug populations occurred sporadically throughout the cotton acreage. In many cases, BW and stink bugs required control.

Boll weevils dispersed extensively in West Tennessee. By late August and early September, weevil adults and larvae were found as far north as Lake County. Secondary pests (e.g., aphids) became injurious in some fields treated for boll weevils in Fayette County. Diapausing boll weevil populations were monitored in September to November with pheromone traps. Substantial numbers of boll weevils were captured in each county surveyed including the majority of counties in West Tennessee and one county in Middle Tennessee. In general, boll weevils and BW/TBW were more damaging than in the past ten years. Thrips and plant bug populations were extremely low.

## Research Progress and Accomplishments

Arizona. Catches of male pink bollworms (PBW) in gossyplure-baited traps 7-14 days prior to cotton squaring were highly correlated to square and boll infestations. PBW egg-sampling for insecticide treatment decisions resulted in a 35% reduction in insecticide use with no reduction in yield.

Strontium added to PBW diets was detected in moths at levels sufficient for migration studies. Lower rates were not a problem and strontium was detected in all plant parts.

Under low PBW densities, three insecticide applications were required on "Deltapine 61" (nectaried, normal leaf, late maturing), and two on an experimental line 'WC-12NL' (nectariless, okra leaf, early maturing). 'WC-12NL' yielded ca. 3.0 bales/acre while 'Deltapine 61' yielded ca. 2.0 bales. Under higher PBW densities, 'Deltapine 61' was treated nine times while 'WC-12NL' was treated six times. Both varieties yield about the same (ca. 2.7 bales/acre). Thus, the experimental PBW resistant line yielded as much, or more, as the commercial cultivar with a 1/3 saving in insecticide costs.

Four short-season cottons had less seed damage by PBW, and one yielded more than the long-season check. Two nectariless, okra-leaf cottons did not have less seed damage, but yielded more lint than the nectariless checks. Cotton leaf crumple virus varied from absent to severe among 27 cottons.

PBW moths in field cages containing nectaried cotton reproduced 21-fold compared to a 15-fold increase in cages of a related nectariless cotton.

The PBW showed a linear response to induction of sex-linked lethal mutations from 1500 to 7500 rads of radiation, but a non-linear response to over 7500 rads.

The (z,z)-isomer, one component of gossyplure when applied to a field of cotton virtually eliminated trap catches of PBW native male moths. For two months, boll infestations were comparable to those from a nearby field treated with insecticides. Thereafter, males were captured in traps baited with an unnatural 9:1 ratio of (z,z)- to (z,e)-isomers. Boll infestations increased to 50% the third month, compared to near zero infestations in the insecticide-treated field. Laboratory-reared moths

were not caught in traps with 9:1 or the natural 1:1 ratios of isomers, indicating physiological differences between laboratory and native moths.

Electrophoretic analysis of *Anthonomus peninsularis*, which is closely related to the boll weevil, revealed several diagnostic loci which could be used to separate these species.

Ethephon at 1.68 kg/ha applied on September 15, 23, or 29 significantly reduced squares and green bolls, with a corresponding decrease in boll weevil populations. Percentage open bolls was increased by the treatment, with no significant reduction of yield. Boll weevils that remain enclosed in bolls until April may live up to 60 days longer than weevils that emerged during the fall and winter. Weevils have emerged from leaf litter under pyramid emergence cages during late winter and early spring.

Ethephon at 1.12 or 1.6 kg/ha and thidiazuron at 0.056 or 0.12 kg/ha reduced the number of green bolls at harvest and the number of diapause PBW larvae without reducing yields. Diapause larval reductions were greater when ethephon was applied on September 3 than on September 10 or September 17.

Summer diapause occurred in TBW with low ecdysteroid titers and cessation of reproductive development.

The sweetpotato whitefly transmitted cotton leaf crumple virus to seedling cotton, resulting in stunted growth, and reduced fruiting and cotton yield.

The optimal temperature for cotton aphid was 27.5$^{\circ}$C for development and fecundity. This temperature is 5$^{\circ}$C higher than that reported elsewhere and may be an adaptation to desert conditions. (USDA - Phoenix).

California. The presence of predacious mites in cotton fields was confirmed for Western Fresno, Kings, Tulare and Kern counties. At some locations these predators appeared to be the major factor causing significant reductions in and, finally, collapse of the tetranychid mite populations. At all but one location the predator was identified as *Typhlodromus (Metasiiulus) occidentalis*. The exception was a field that contained this predator plus *Amblyseus tularensis*.

Whiteflies were present in many cotton fields in the San Joaquin Valley. At most locations, numbers were low compared to previous years. Generally, only the greenhouse whitefly was observed, but the banded-winged whitefly occurred in low numbers at two locations. Parasite emergence from pupal stage whitefly collections ranged between 0 and 90 percent. The parasites appeared to be Eretmocerous haldemani and Encarsia (Aleurodiphilis) pergandiella.

Four cotton fields, which had almond orchards to the north, were monitored weekly for spider mites. The level of resistance to dicofol and propargite were followed. Almonds were a major host source of the mites, and control in cotton was achieved only after they were controled in almonds. Levels in resistance varied greatly week to week indicating a potential weakness in the interpretation of bioassay results which are taken at one point in time. (U. C. Davis).

Florida. Progress was made on identification of the neural circuits of the BW moth that are responsible for specific sensory inputs from the acoustic and mechanoreceptor sensors and the motor nerve outputs to muscles that control specific behaviors. This information will be useful in developing control procedures that utilize the insects response to olfactory, acoustic, and visual stimuli.

An oviposition-stimulating kairomone mediating egg laying by the braconid Microplitis croceipes (Cresson) females was discovered in host hemolymph and partially characterized. This agent, when added to agar, elicits oviposition. It is anticipated that it could be used to acquire eggs which would than be cultured in vitro. Recent efforts on the in vitro culture of M. croceipes have focused primarily on isolating and chemically characterizing a factor in host hemolymph that is required for early egg development. This egg development-stimulating protein (EDSP) also is present in hemolymph of the non-permissive host Manduca sexta, which has been used as a convenient source for EDSP. Data suggest that EDSP may function as a carrier protein, releasing a smaller molecule which then activates the parasite's eggs. (USDA, Gainesville).

Georgia. The evaluation of chemigation (application of insecticides through overhead sprinkler systems) indicated some progress was made in the control of boll weevil populations. Previous work showed a

lack of residual control of boll weevil compared to conventional application methods. The use of technical grade methyl parathion mixed in Orchek oil and the use of technical grade azinphosmethyl mixed in soybean oil provided improved performance over previous results.

Twenty strains of cotton were evaluated for their potential resistance to *Heliothis* spp. populations. Several strains yielded as well or better in the minimum treatment block compared to the "protected" block. Among the most notable were MISCOT 7913-51. The TAMCOT strains and the ARS-TX-HIGOS strains provided uniform yields between the three treatment regimens, however, yield was not comparable to that of other strains. The LA-HG strains provided good yield and apparent good tolerance to *Heliothis* injury. Feeding studies indicated slower growth, longer life cycles, and decreased pupal weight of TBW larvae on strains with high gossypol content.

There was no change in dose response to pyrethroid materials against the TBW using topical application techniques. The vial technique indicated greater than 95% mortality of male moths occurred at the 5 ug/vial dose and greater than 90% mortality was achieved at the 1 ug/vial dose of cypermethrin. These results together with no abnormal reports of field control failures indicate that resistance to pyrethroids has not yet been manifested in Georgia cotton fields.

Laboratory and field studies indicated good ovicidal activity of Mitac® and thiodicarb against *Heliothis* compared to chlordimeform. Methomyl also provided good results, however, reddening of foliage occurred in the field trials where repeated applications were made.

Applications of biological insecticides as well as insect growth regulators did not provide control of *Heliothis* larvae comparable to that of pyrethroid materials. Early season applications of biologicals did not provide increased yield over untreated plots; early applications of pyrethroids and chlordimeform did not either. The addition of Entice™, a feeding stimulant, appeared to enhance the activity of the biologicals, as well as thiodicarb, a stomach poison. (Univ. Georgia).

*Louisiana* Wire-cone traps baited with synthetic sex lures of the BW and the TBW were monitored over a seven year period (1980-1986) in Louisiana. Mean

numbers of male BW captured in traps were much higher than TBW for every month during the study. The highest capture of TBW and BW males occurred during August and September. The TBW represented more of the total *Heliothis* population collected for these months than was observed earlier in the season. Data for recent years (1984-1986) indicate that the percent of the *Heliothis* population represented by the TBW has increased. TBW increased in the *Heliothis* spp. trap catches from 11.7 and 16.1% during 1984 and 1985 to 41.5% during 1986. In addition, the TBW consistently comprised a higher percentage of the population in June and September than in July and August. A positive correlation was observed between the total of TBW and BW male moths captured in pheromone traps and oviposition in cotton fields. Correlation coefficients with $R^2$ values of 0.69, 0.48 and 0.83 for 1984, 1985 and 1986, respectively, indicated this relationship to be highly significant for approximately a 5-6 week period during late June and July.

During September 1986, survival of TBW male moths in glass vials dosed with 10 ug of cypermethrin (a dose that kills all moths except those resistant to cypermethrin and other pyrethroids) was 33-37%. During 1987, survival at the same dose was 20, 13, 18, 12, and 15% for the months of May, June, July, August and September, respectively. These data indicate that the Tri-State Pyrethroid Resistance Management Plan was successful in reducing the proportion of resistant moths (genotypes). Monitoring data also revealed that the level of pyrethroid resistance in the southern part of the cotton production area in Louisiana is generally lower than in the northern part.

Dosage-mortality values were determined for eight pyrethroids bioassayed against a fenvalerate-resistant strain of TBW, collected during 1986. A broad spectrum of cross-resistance was detected to permethrin (16X), fenvalerate (19X), fluvalinate (17X), cypermethrin (9X), biphenthrin (12X), esfenvalerate (10X) and deltamethrin (7X), although only cypermethrin, fenvalerate and permethrin have received extensive field use. Cross-resistance to cyhalothrin-K (Karate®) was consistently low (1-2X) when tested against several strains of the TBW. Pyrethroid-resistant cultures bioassayed with methyl parathion and profenofos exhibited 2-16X and 4-5X respective levels of resistance. Methyl parathion

resistance was correlated ($r=0.99$, $P<0.014$) with increasing levels of fenvalerate resistance. Pyrethroid: profenophos combinations tested against pyrethroid-susceptible and resistant strains of TBW indicated that profenofos synergized fenvalerate and cypermethrin, thus increasing the toxicity of these compounds, but it did not reduce the corresponding level of pyrethroid resistance. (Louisiana State University).

Mississippi. A state-wide monitoring program for pyrethroid resistance in TBW was initiated in 1987. Adult TBW (>10000 moths) captured in pheromone traps were exposed to cypermethrin-treated vials (5 and 10 ug per vial) and observed for mortality. Results indicate that pyrethroid-resistant TBW are widely distributed but that the frequency of the resistant individuals varies. The frequency tended to increase as the growing season progressed. Colonies of TBW were established from larval populations collected from some locations. These colonies were studied by topical application as well as treated-cotton techniques, and results were similar to those obtained in the adult monitoring program. Similar studies with the BW showed no measurable levels of pyrethroid resistance.

Research on the seasonal history and damage potential of clouded plant bugs, was completed in 1987. Results indicate that the insect overwinters as an egg and increases in population density on several wild host plant species prior to moving to cotton. Cage experiments suggested that damage is similar to that of the tarnished plant bug, and feeding resulted in numerical increases in vegetative branches and delay of crop maturity.

Several studies on the fall armyworm were completed in 1987. Larvae tend to disperse soon after occurrence at suitable feeding sites. Early-instars tend to feed on leaves and bracts while later instars prefer fruit. The effect of the various types of feeding on probability of harvest was determined. Survival on cotton was low.

Research on TBW sensory responses indicates that given a choice of cotton and ground cherry in a close-range situation, female moths depend primarily on contact chemoreception (by tarsal sensilla) and mechanoreception (by tarsal and ovipositor sensilla) and not on olfaction or vision to discriminate between

the two plants. Studies using whole plants suggest that moth preference in descending rank is: tobacco, velvet leaf, cotton, pigeon pea, ground cherry, geranium, lupin, and crimson clover. In studies using terminals only, the order of moth preference is: tobacco, velvet leaf, clover, geranium, cotton, lupin, pigeon pea, and ground cherry. Females apparently prefer plants with an erect growth habit over those with a procumbent growth habit in a choice situation. Further, oviposition is very highly and positively correlated with plant hirsuteness. There are no chemicals on the surfaces of the plant species tested which are attractive to TBW.

Stimulation of tarsal or antennal contact chemosensilla of adults with sugars resulted in proboscis extension. In preliminary electrophysiological studies, these sensilla respond to sugars and salts in a dose-dependent manner. Two cells in tarsal chemosensilla respond to NaCl. One cell responds to KCl and one cell also responds to sucrose. Fifty percent of the individuals responded to a 0.02 M concentration; a 0.05 M concentration of sucrose elicited a maximal response. Tarsal sensilla also responded to extracts of tobacco, cotton and ground cherry; however, the patterns of response, spike amplitudes and frequencies are different to the three species. TBW tarsi have two types of contact chemosensilla and one type of mechanosensilla. The antennae have several types of olfactory sensilla in addition to contact and unidentified sensilla. The ovipositor has mechanosensilla and a few contact chemosensilla.

Presence of conspecific eggs did not affect acceptance by females for oviposition. Plants with larval damage were less preferred over healthy plants. There is no effect of water stress (stressed for up to seven days) or nitrogen concentration (0 to 3.7 g ammonium nitrate/potted plant) on acceptance by female moths. Plants that were five and eight weeks old were preferred over plants of two and thirteen weeks of age.

A study on the timing and duration of plant bug infestations on cotton resulted in some delay in maturity due to plant bugs. No differences were observed in yield or the week in which the cotton reached 60% open bolls.

There were no quantitative or qualitative differences in pheromone production between lab-reared fall armyworms originating from Mississippi and

Honduras collections. However, the Mississippi population exhibited a bimodal rhythm of calling during scotophase with a peak at ca. 24 h while the Honduras females exhibited a unimodal rhythm with peak calling at 3 h. The differences in peak calling may be attributed to latitude and consequent temperature differences between Mississippi and Honduras. The two strains appear to be genetically similar and both sexes mated successfully in reciprocal crosses.

Tests to establish the effects of antibiotic combinations on the longevity of boll weevils sterilized by irradiation indicate that mortality was reduced 60% and 12% at day-5 and day-10 post-irradiation, respectively, when weevils were fed antibiotic combinations in the diet five days prior to irradiation. Insect feeding was reduced 75% over the 10-day post-irradiation period. Protein and lipid digestion (wt-wt) was reduced 59 and 29%, respectively, over the same period. Longevity can be extended from day-5 to day-10 by maintaining a bacteria-free insect.

BW reared on tetracycline containing diets had lower mortality but required more time to reach the pupal stage. Tetracycline diffuses and dissipates readily into and out of insect blood and tissues It reduces biosynthesis of high molecular weight proteins in hemolymph. Apportionment of tetracycline in the pupal tissue is uneven.

In small plot tests, early season thrips populations were reduced by all recommended compounds tested. Granular in-furrow treatments tended toward numerically higher yields than foliar applications. Among foliar applications, acephate at 0.2 lb AI/acre gave the best results five days following the first application.

Control of late season TBW in small plot tests was best with pyrethroids at full, recommended rates in combination with an organophosphorus compound compared with the organophosphorus material or pyrethroids alone. Addition of 0.125 lb AI/acre of amitraz to pyrethroids tended to improve control. Application of cypermethrin at 0.06 lb AI/acre in combination with chlordimeform or thiodicarb at ovicidal rates resulted in ca. 80% egg mortality (ca. 70% dead in shell). These values were equivalent to those of profenofos at 1.0 lb AI/acre in combination with chlordimeform, amitraz and thiodicarb at 0.125 lb AI/acre, were 0.37%, 0.32% and 0.55%, respectively.

Endosulfan in combination with biphenate at 0.3 and 0.04 lb AI/acre, respectively, gave excellent aphid control in small plot tests. Addition of chlorpyrifos at 0.125 lb AI/acre to methyl parathion did not enhance control over methyl parathion alone. Monocrotophos, dicrotophos, and methamidophos at 0.2 lb AI/acre, phosphamidon at 0.1 lb AI/acre and RH 7988 at 0.03 to 0.12 lb AI/acre gave good control. Chlorpyrifos and methyl parathion at 0.25 lb AI/acre were less effective after the second application than other entries in the test.

Spray chamber tests with miticides indicate that fenpropanate is effective; more so on adult mites than immatures. ABG6162A at 1 qt/acre in combination with biphenate at 0.02 lb AI/acre was effective on adults and immatures. Dicofol had knock-down effect at 24 h but allowed recovery (molting or egg hatch) by 72 h. No compound gave complete control when sprayed on the abaxial leaf surface in a spray chamber.

Populations of western flower thrips were reduced significantly by applications of monocrotophos 0.75 lb AI/acre and methamidaphos at 0.75 lb AI/acre compared to the untreated check (3 days post spray). Dimethoate at 0.5 lb AI/acre was ineffective. Addition of chlordimeform to low rates of monocrotophos did not increase efficacy and chlordimeform alone was ineffective. Monocrotophos and methamidaphos at 0.5 and 0.4 lb AI/acre, respectively, and other systemic insecticides were moderately effective following the second application. No compound tested was completely effective. The moderate infestation did not affect the number of bolls or boll weight among treatments. (Mississippi State University).

A multicellular larval rearing system for TBW was evaluated for <u>in vivo</u> production of the multicapsid nuclear polyhedrosis virus isolated from <u>H. armigera</u> (Hubner). Various concentrations of virus were sprayed on TBW diet, and the virus was harvested and processed at six or seven days post-treatment. There were significant differences in yield due to inoculum, and results demonstrated the method would be efficacious.

The potential of oil-soluble dyes as indicators of effective control of <u>Heliothis</u> spp. emerging from wild geranium field plots was evaluated. When part of a test area was treated with a red dye and part with a blue dye, both red and blue marked individuals were detected. When part of an area was treated with a

blue dye and the remainder treated with the red dye plus a virus, only blue marking was detected.

The effectiveness of several formulations containing both protectant and feeding adjuvants (applied as wettable powder or in new microgranular formulations) and three new strains of Bacillus thuringiensis was tested for Heliothis control in cotton. Although control was not comparable to control achieved with chemical insecticides, all treatments reduced populations and increased yields compared to untreated cotton.

The possible use of the exotoxin, Thuringinsin®, combined with B.t., virus, and a feeding adjuvant for TBW control was tested. Results indicated a positive effect from the addition of the exotoxin in control, however the addition of virus and feeding adjuvant at the recommended rate did little to improve performance.

In wind tunnel tests, the number of landings per fifteen minutes observation time for thirty virgin male M. croceipes in response to a small cage located upwind containing virgin females was recorded. There were 63 landings in the time allotted. Male M. croceipes were also observed to respond via upwind orientation, landing, wing fluttering, and copulation attempts to solvent extracts of females. In the wind tunnel containing 70-80 males, 25-30 positive responses were elicited within one minute by a solvent extract of the female. The attractancy of female extracts to males in the cotton field was demonstrated. Isolation, identification, and synthesis of the pheromone could lead to development of a monitoring technique for M. croceipes, which could predict parasite density and levels of biological control.

In a roadside vegetation study with two species of grasses and six species of legumes and all possible combinations thereof it was determined that significantly higher populations of $F_1$ Heliothis spp. larvae developed in the treatments containing crimson clover than in any of the other treatments and that none of the treatments had a significant effect on numbers of ground beetles, lycosid spiders, or total numbers of spiders.

Pheromone trap catches of male Heliothis in Washington Co., Mississippi show the initiation, peak and termination of the overwintered adult population of the BW occurred ca. March 20-23, May 8-14 and May

28 and that of the TBW ca. April 17-20, May 8-14 and May 28, respectively. The overwintered adult population was composed of 31.1% BW and 68.9% TBW.

The initiation, peak and termination of the $F_1$ adult population of the BW occurred ca. May 29, June 26 and July 2 and that of the TBW ca. May 29, June 19-25 and July 3-9, respectively. The $F_1$ adult population was composed of 18.6% BW and 81.4% TBW. Of a total of 34,405 Heliothis spp. males captured between March 19 and Sept. 15, 32.3% were BW and 67.7% were TBW.

First year results from data collected in the Mississippi Delta as part of an ARS pilot test, "Advancement of Area-Wide Management of Heliothis spp. Through Pheromone Trap Calibration and Measurement of Mesoscale Movement" indicate that (1) trap captures in cotton reflect species composition of field populations; (2) trap captures reflect population fluctuations; and (3) trap captures are related to developing field populations in cotton.

Various insecticides and insecticide combinations were evaluated for their ovicidal activity against TBW eggs on cotton. Combinations of chlordimeform or thiodicarb with either cypermethrin or profenofos were the best insecticides tested and had effective residual ovicidal activity as long as 72 h after application.

In small plot tests several insecticides and insecticide combinations were evaluated for control of Heliothis. A growth regulator, UC-84572, gave good control of Heliothis in late August when used alone at 0.08 lb (AI)/acre and when alternated at 0.08 lb (AI)/acre with applications of cypermethrin (0.06 lb (AI)/acre or thiodicarb (0.25 lb (AI)/acre). It was also effective at lower rates when used in combination with chlordimeform, cypermethrin, or thiodicarb. Thiodicarb, cypermethrin, esfenvalerate, Capture® and Karate® all gave good control of Heliothis larvae at recommended rates in late August. Combination treatments of thiodicarb (0.3 lb (AI)/acre) with cypermethrin (0.03 lb (AI)/acre), profenofos (0.5 lb (AI)/acre), or acephate (0.5 lb (AI)/acre) also gave good control of Heliothis.

Resistance to acephate and dimethoate by the tarnished plant bug from five locations in the mid-Delta of Mississippi and two non-Delta locations was determined with a liquid scintillation vial bioassay for adults. Tarnished plant bugs from the Delta locations had little resistance to acephate as compared to the two non-Delta locations. Tarnished plant bugs from the Delta locations were tolerant to dimethoate and had $LC_{50}$ values as much as five times higher than $LC_{50}$ values found for tarnished plant bugs from the two non-Delta locations.

In a large experiment the use of aldicarb and ethephon resulted in cotton that was eight days earlier than cotton that received ethephon only. Yields were higher in cotton treated with aldicarb at 0.50 and 0.75 lb (AI)/acre than cotton treated with Thimet® at the same rates.

In mark-recapture experiments, over 50,000 parasitic wasps were released and over 2,000 were recaptured in six 2 ha plots of cotton artificially infested with various densities of TBW larvae. The proportion of hosts parasitized increased with host density, although search rate was independent of host density. The density of adult M. croceipes and Cardiochiles nigriceps increased with host density, indicating that this was the reason for density-dependent parasitization. Parasitoid aggregation appeared to result from accumulation in areas of high host density, rather than initial differences in initial dispersal of emerging wasps to such areas. Simulations with a mathematical model of host-parasitoid population dynamics indicate that this aggregation could be important for the success of augmentative releases of the parasitoids to suppress Heliothis populations.

To determine the effects of ethephon removal of early squares on cotton development and yield, three field experiments were carried out. The ethephon treatments significantly increased the number of harvestable bolls in one experiment, boll weight in two experiments, micronaire in all three experiments, and lint yield in one experiment. A split application of (500+300 ppm) increased yield 16.6%. (USDA-Stoneville)

The development of technologies for adapting Heliothis production to a mechanized tray rearing procedure enables mass propagation of cannibalistic larvae in sealed cells with autoclaved diet. Prototype equipment to mechanically harvest eggs from oviposition substrate and pupae from sealed trays has been developed, and can be adapted to a mass propagation program. The procedures and equipment developed can be applied to yield 140,000 pupae (1 implant unit) to 400,000 pupae (2 implant units) per day if adequate facilities are available. Pupae reared in trays are exceptionally free of microbial contaminants.

A major effort also is underway to develop and adapt automated M. croceipes rearing in conjunction with the Heliothis rearing technique. Parasitoids

are being introduced to trays of diet containing several TBW larvae; ca. 90% produce parasitoid cocoons depending on the method used for holding parasitized larvae.

A cooperative project with New Mexico State University is underway to develop an automated system for separating the pupae of the TBW by sex via computer imagery. Preliminary investigations on image production and delivery systems are ahead of schedule. Prototype equipment has been developed, such as the stage on which pupae will be monitored. Software has been developed for measuring pupal length and width, and decision systems for sorting pupae by length and width are in place. An assessment of pupal damage associated with handling systems is underway. TBW and BW pupae are continually monitored for pupal anomalies that may prove useful as genetic markers for rapid recognition of the sexes. Adults also are monitored for genetic markers that may facilitate the recognition of mass-reared/released insects.

During 1987, a cooperative test of sterile weevil aerial releases was conducted by ARS and APHIS. Results were encouraging and plans are to continue the test on approximately 4,500 acres in Western Alabama. Results of the 1987 test demonstrated interactions of the sterile weevils with the wild weevil population; fertility was reduced to approximately 39% in field populations that were moderate to low during releases.

Over the 9-week period of the sterile boll weevil release test, 11.2 million sterile weevils were released. Antibiotics were added to the weevil diet as a prophylactic treatment for microbial contamination, but their value is unknown. Quality control data generally recorded low levels of contaminants that did not significantly impact field longevity. Liberal use of antibiotics as a prophylactic treatment is expensive and encourages development of resistant bacterial strains. Survey tests using aged weevils from the oviposition colony that were found to contain infinite levels of microbes were irradiated and caged in the field to monitor longevity. $LT_{50}$ rates of 11 days were equivalent to those of weevils exhibiting low contamination levels. The diet was supplemented with beta carotene to improve weevil vision.

Studies to improve survival of weevils during holding periods was accomplished by using a chilled environment (12° C) to reduce metabolic heat stress. Additionally, the reduced weevil mobility enabled improved handling procedures for weighing and distributing weevils. Airplane pilots carefully monitored aerial dispersal and proper opening of cardboard release tubes.

Greenhouse and field cage studies of male longevity were conducted on all but one of the forty-seven groups released. $LT_{50}$ (the number of days after irradiation on which mortality reached or exceeded 50%) was 9.1 $\pm$ 0.2 days. $LT_{100}$ (measured on only eight of the forty-seven groups released) averaged 11.0 $\pm$ 0.3 days. Data indicate that they were probably effective in the field for at least seven days after release. On this day 23 $\pm$ 2.2% mortality had occurred. Thirty-five of the groups tested had $LT_{50}$s of at least nine days and only one group had an $LT_{50}$ of less than seven days. Using $LT_{50}$ as a measure of quality, the weevils released during the course of this test were better than those of any previous test using mass-reared, mass-sterilized weevils. They lived about 18% longer than the 7.7 day $LT_{50}$ seen in the last mass-release test conducted in South Carolina in 1985.

The longevity, attractiveness, and mating ability of the radiation resistant strain (RR) of boll weevil developed at Fargo, ND, were tested. The strains compared with the resistant strain were the original strain from which the resistant strain was selected (CP) and the strain presently used at the R.T. Gast Rearing Laboratory. All weevils were reared and irradiated at the Metabolism and Radiation Research Laboratory, Fargo, ND, and shipped by air to Mississippi State for greenhouse and field cage testing. RR males lived 26.5% longer ($P<0.01$) than those of the other two strains ($LT_{50}$=19.5 days for RR > 15.7 days for CP = 15.2 days for MR). Traps baited with males of the RR strain captured more feral weevils than traps baited with males of either of the other two strains. Only a small number of matings were conducted on the 7th, 10th, and 14th days after irradiation, but males of the RR group were able to inseminate more females on day 14 than males of the

other two groups. Therefore, males of the RR strain performed better in all three of the categories tested than males of either the CP or the Gast strains. Based on these data, the RR strain might be expected to be more competitive in the field than the other two strains.

Antibiotics added to larval and/or adult diets fed to boll weevils sterilized with diflubenzuron plus irradiation had increased locomotor activity for days 4-6 over weevils receiving no antibiotics.

Quality control tests of sterile boll weevils released in North Alabama (Fayette area) proved to be 99.9% sterile. Treated males were 73% as attractive to females as normal males for four days, post treatment in laboratory trapping studies as well as flight studies. In locomotor studies for five days post-treatment sterile weevils were 61% as active as normal weevils.

There were statistically significant increases in pheromone production when Beta Bisabolol and juvenile hormone III were added together to the fat body incubation mix. This indicates that these compounds are either precursors to pheromone production or act to increase pheromone production in some other manner.

Conspecific effects were shown for aggregation pheromone production by male boll weevils. A single mating of males on day 3 following emergence lead to a significant decrease within 48 to 72 hours in quantities of aggregation pheromone components I, II, and III, as well as total pheromone production relative to unmated control males. Recovery of production of each pheromone component as well as total pheromone production occurred within 3 or 4 days following mating to levels on days 9 and 10 which exceeded control males at this time. These results suggest that levels of pheromone may signal mating readiness and also facilitate genetic diversity since recently mated males would be less attractive to prospective mating partners. Production of the aggregation pheromone was also diminished when males were housed with females. These results indicate a possible need for the separation of males from females prior to use in sterile male release programs.

After feeding on cotton, male boll weevils release an aggregation pheromone in their frass which attracts both males and females for feeding and mating. This pheromone consists of four components. One of these components, grandisol, because of its unique chemical structure, may exist in two forms (enantiomers). These enantiomers, (-)-grandisol and (+)-grandisol, are mirror images of each other. In a previously published study, (-)-grandisol and (+)-grandisol were equally attractive to the boll weevil. The current neurobiological and quantitative behavioral studies demonstrated (+)-grandisol to be active while (-)-grandisol possessed little or no activity. In fact, (-)-grandisol was slightly inhibitory, and appropriate pheromone components could increase trap catch over the currently used mixture of (+)-grandisol. Furthermore, pheromonal communication by boll weevils in the field might be disrupted by (-)-grandisol.

Analogues of the two geometric isomers of compounds III and IV of the boll weevil aggregation pheromone were synthesized in which the alpha-vinylic proton or the aldehydic proton were replaced with fluorine. These isosteric substitutions alter charge distribution and reactivity of the enal system, as documented by spectroscopic changes and changes in reactivity, the electrophysiological activity of the acyl fluoride analogues is two orders of magnitude lower than that of III and IV. In contrast, the EAG response of female antennal receptors of the alpha-fluoro analogues of III and IV showed thresholds similar to or lower than those for the natural pheromone components. It was shown for the first time in a beetle that changes in the sensitivity of the peripheral receptor system for both host plant odors and the aggregation pheromone during maturation are adequate to explain the onset of sexual behavior as determined in previous behavioral studies. Results indicate that agents which might modulate receptor responsiveness could be used to control mating and possibly host plant finding by certain insects. Traps were baited with lures containing 10 mg grandlure in ratios of components chosen to mimic pheromone produced by live male boll weevils. Generally, a mixture containing less than one half the standard amount of aldehyde components captured the most in spring and early summer while the standard ratio captured the most during late summer and fall.

These results showed that absence of components I, II or IV from the four component blend lead to loss of activity when in competition with the four component

blend. However, removal of III did not have a significant effect. These field studies correlated well with electrophysiological studies which showed antennal olfactory receptors of both male and female weevils significantly more sensitive to IV. These results indicate that the boll weevil pheromone is composed of only three compounds, i.e. I, II and IV. So, pheromone traps for monitoring populations in the field will be attractive only if each of these three components are present.

No differences in field competitiveness were found between sterile irradiated weevils reared on the standard Gast diet and the same diet supplemented with beta-carotene, even though photic responsiveness of these two groups was different. However, feeding on cotton by weevils reared on the Gast diet increases electroretinogram responses to that observed of field-collected and carotenoid-supplemented weevils.

A rule-based expert system was used to adjust numbers of overwintering boll weevils, larval mortality, insecticide spray threshold, and spray interval for a boll weevil simulation model. The model then simulated a realistic population over time and determined the number entering diapause and exiting the field each day. Dispersal distances were simulated using parameters such as inherent flight ability and meteorological factors.

A geographic information system has been developed that allows tabular and digitized (maps) data to be presented on a computer screen. The tabular data might be weevil counts from traps or other such field data. This can be combined with maps of the fields. Overlays can also be digitized so that roads, for instance, can be presented with fields.

A large number of parasitic and predaceous Hymemoptera were acquired during the Optimum Pest Management Trial Experiment in Panola County, Mississippi, the Boll Weevil Eradication Trial in Raleigh, North Carolina, and the Biosystematics of Anthonomus project. A study was initiated in October 1987 to identify and curate the Hymenoptera from these previous projects, and to prepare publications based on the extensive data associated with the specimens. A total of 6,470 were collected in Panola County and North Carolina. Several hundred other specimens were collected during the Biosystematics of Anthonomus project. Of the 6,470 specimens, 5,067 (78%) have

been identified and these represent 107 species in 132 genera. Identifications of 285 Braconidae and Ichneumonidae have not been confirmed yet by specialists at the U.S. National Museum. Data from identified specimens are being coded for entry into a data base program for sorting and retrieval. A new species of platayastrid wasp has been identified from material collected on alternative hosts of the boll weevil.

Sixty-five participants in all 14 cotton growing states cooperated in a pilot test of GOSSYM/COMAX. Most locations were commercial farms, but some were experiment station efforts and three to four were efforts by farm consultants. GOSSYM/COMAX is being extended to handle different cotton varieties, cultivation, $NH_4$ fertilizer, and other changes in input/output representations. Initial work to handle pest disturbances was also incorporated into the system through the use of an in-season adjustment. This approach worked well and will be improved in the coming seasons.

A rule-based expert system for pest management is being developed and incorporated into GOSSYM/COMAX. It uses the current recommendations of the Mississippi Insect Control Guide (Cooperative Extension Service). This "first-generation" pest management system has been developed with the idea of expanding it into a model-based reasoning system that will give farmers a choice of management options for dynamic pest problems. A framework has been developed to accept input data from scouting reports and computer simulations. The input data are processed, pest population and damage levels are determined (using models that presently include only GOSSYM), a comparison is made with an economic threshold value for individual pests, and a control/no control recommendation is given. If control is recommended, the pesticide selection routine generates a list of pesticides by order of efficacy and economics for the targeted pest(s). Rates and precautions are provided. Each spray event reduces the population, after which a model re-initiates population growth (because the system presently does not contain the pest population models, scouting information is used to maintain appropriate population levels). Scouting information is used to re-initiate and re-align pest population levels, host-plant phenology, and other factors that directly or indirectly impinge on the simulations. These data will keep the simulations more closely aligned to the crop even with pest disturbances.

The groundwork was laid to assess scouting data during 1987. Hand-held computers were programmed and used in the field to log insect and crop phenology data. By automating the scouting reports, these data can be immediately downloaded into the computer and used by the expert system. Further assessment of scouting methods and data collection will be made to initialize and use the system for multiple purposes.

New information discovered in the last two years is being incorporated into a revised crop model (GOSSYM II) which will have multiple time steps within a day, new plant physiology, soil physics, computational methods, and model structure.

Efforts to establish cooperative ties with other modeling groups working on cotton insects have begun with encouraging results. Documentation of existing process/population models is being obtained, as are computer codes of the models. The following extant models are being considered for incorporation into the expert system: MOTHZV (developed by USDA-ARS, College Station, Texas), TEXCIM (Entomology Department, Texas A&M University), CIM (Departments of Industrial Engineering and Entomology, Mississippi State University), HELSIM (Department of Entomology, North Carolina State University), Texas Boll Weevil Model (Departments of Industrial Engineering and Entomology, Texas A&M University), and other process-population models; e.g., HELDMG (USDA-ARS, Florence, SC).

Experimental work was directed at understanding the mechanisms behind diapause induction of the boll weevil. This ongoing work will provide a foundation for modeling the process and developing improved diapause control tactics and eradication technology. Research is underway at understanding and quantifying cotton square growth and development. This work is relevant to both insect/host interactions and to GOSSYM. (USDA, Mississippi State).

Missouri. In the past few years control failures have been reported where methyl parathion was used as the preferred insecticide for BW control. Larvae were hand collected from cotton which had been sprayed with a sugar solution. The population was 97% BW and 3% TBW. A laboratory colony was established for each species. Larvae from the $F_1$ and $F_2$ generations were tested for methyl parathion tolerance as measured by topical bioassays. During 1987 all populations of *Heliothis* were considered susceptible. (Univ. Missouri).

New Mexico. Data from experiments testing the effects of early season insecticides on insect populations and yield reveal that in 1986 thrips and Lygus were controlled best by Cymbush® followed by acephate, chlordimeform, and the check. However, there were no significant yield differences in first pick seed cotton. In 1987, all treatments were more effective than the check for Lygus control, but not significantly different from each other. Predatory populations were decreased most by Cymbush® followed by acephate, aldicarb, and chlordimeform. Results were observed up to 26 days after treatment. There were no significant yield differences in first pick seed cotton.

Absolute Insectavac samples from cotton in 1984 and since suggests mobile adult Lygus and adult predator populations exist in much higher populations than non-mobile immature populations. An experiment was designed to document adult migration from alfalfa to cotton. At cutting, mobile insect forms appeared to migrate to adjacent uncut alfalfa rather than to cotton. Assuming there is constant invasion of adult insect forms from alfalfa to cotton, it appears actual residues and not early season insecticide kill of beneficials is responsible for the relative low densities of predators in treated cotton mid-season. Killing the beneficial complex early-season may aggravate the BW problem later. That plus the fact that yield increases have not yet been shown for early-season pesticide applications negates the need for early-season pesticide applications for thrips and Lygus control under the conditions of tests in New Mexico.

Future early-season pesticide application trials will be applied a month earlier (June 1) to try to reduce negative density effects on the beneficial complex. Objectives will be to determine early-season pesticide effects on yield, earliness, insect densities, and residual effects. Shifting maturity forward by one to two weeks with early-season pesticide applications without inducing resistance or adversely affecting the beneficial complex could be of significant value in short growing-season years. (New Mexico State University).

North Carolina. The egg threshold for bollworm control was confirmed and further refined. The utility of this threshold is now being evaluated for mixed populations of BW and European corn borers.

Research on the green stinkbug included studies on developmental rates, reproduction and damage characterization. Cotton was found to support the entire life cycle for this species.

Aldicarb provided greater thrips reductions, longer residual control, earlier maturity and greater yields than the alternatives tested - i.e. disulfoton, phorate and various acephate foliar sprays. (North Carolina State University).

Oklahoma. A model was developed to simulate insect movement within a field. The model was based on a zero range interaction model with Bose-Einstein speeds taken from a statistical particle distribution example. Field verifications have shown that fleahoppers, convergent lady beetles, BW and collops fit the model well. They are independently distributed and have zero range interaction. This basically means, that the insects in one cell (plants in this case) have no influence on insects in adjacent cells. The verification showed that cotton aphids did not fit the model.

Feeding preference tests were conducted in the field and laboratory to determine the distribution and preference of the various life stages of the BW. Results demonstrated that early instars had a strong preference for young tender plant tissue and that this tendency weakens as larvae mature.

Nine different chemical treatments were evaluated for *Heliothis* control. All treatments reduced damage levels significantly (seasonal means) when compared to the untreated check. Cyfluthrin + sulprofos (0.0125 + 0.5 (AI)/acre) had the lowest numerical damage followed by chlordimeform + thiodicarb + profenofos (0.125 + 0.125 + 0.5 lb (AI)/acre); permethrin 25 WP (0.04 lb (AI/acre) had slightly less damage then EC formulations of Cymbush (0.04 lb (AI)/acre) and was equal to fenvalerate 0.1 lb (AI)/acre. TBW resistance in the South Central Research Station, Chickasha and in the Altus irrigation district was measured with the treated vial method. It appeared that no resistance existed during the course of the study. (Oklahoma State University).

South Carolina. In a replicated small plot field test, aldicarb was applied in-furrow at planting time at 0.30, 0.50 and 0.75 lb (AI)/acre. All treatments produced a significant reduction in thrips populations compared with controls. The highest rate of aldicarb significantly reduced thrips damage to cotton seedlings compared with the lowest rate.

Four insecticide treatments (cypermethrin, B.t., B.t + chlordimeform, and chlordimeform at 0.06, 12 BIU, 12 BIU + 0.125, and 0.125 lb (AI)/acre) were evaluated against Heliothis spp. at four thresholds: 1,5, and 20 eggs/100 terminals; and the Clemson recommended larval/damage threshold. Heliothis spp. population densities were abnormally low in all plots throughout the season. Cypermethrin at all thresholds except larval/damage significantly reduced square damage compared with the untreated, but differences among cypermethrin thresholds were not significant. The B.t. + chlordimeform 1-egg and 5-egg thresholds signficantly reduced square damage compared with the untreated, and the 1-egg threshold for chlordimeform significantly reduced square damage compared with the larval/damage threshold and the untreated. Data for larval densities and yields lacked significance. Population densities of beneficial arthropod species were reduced sharply by cypermethrin but not by B.t. or chlordimeform.

Six early-season applications of chlordimeform (0.125 lb. (AI)/acre) to nine cotton cultivars, beginning at the four-leaf stage, had no significant effect on square, boll, or white bloom population densities. Percent first pick and total yield also were unaffected. A planting-time application of aldicarb banded over the row at 1.5 lb (AI)/acre had no significant effect on earliness or total yield. (Clemson University).

The effect of different levels of gossypol on larval developmental rate was studied. BW larvae were reared on diets containing 0, 0.05, 0.10, 0.15, 0.20, 0.25, or 0.30% gossypol. The experimental temperatures were 18.3, 23.9, 29.4, and 35°C. The date of pupation and adult emergence, and daily weight gain were recorded. As the gossypol level increased, times to pupation and adult emergence also increased. Daily weight gain decreased as the gossypol level increased. These data will be used in a Heliothis model to study the effect of gossypol on Heliothis population dynamics.

The BW was reared on Carolina geranium and artificial diet at temperatures from 15.5-35°C. Mean developmental rates were not different between the two food sources. However, larval survival and pupal weights were lower when larvae were reared on geranium than when reared on artificial diet.

Square, small boll, and medium boll shed in McNair 235 cotton was not significantly different between caged plants exposed to 0, 1, or 2 green or brown stink bugs. The number of harvestable bolls was reduced by stink bug feeding, but dry weather followed by showers during the boll opening period caused fruit loss equivalent to stink bug feeding. Exposure of squares, small bolls, and medium bolls to feeding by green and brown stinkbugs for 24 to 48h did not cause significant differences in fruit shed or percent hardlock cotton over unexposed fruit. However, the percentage of damaged bolls and unopened locks was greater after stink bug exposure.

Feeding studies with the spider Phidippus audax (Hentz) spiders indicated that they fed as readily on predaceous insects as on pest insects. Selectivity was shown for soft bodied species over several beetle species, particularly the coccinellids, Hippodamia convergens and Coleomegilla maculata. (USDA, Florence).

Texas. An economic injury level model was developed for the cotton fleahopper in the Coastal Bend area. The model predicts percent yield change for varying levels of cotton fleahopper infestation. The model was developed for SP-21S, SP-21, CABCS, CAMD-E, SP37H, and Stoneville 213. Basic information for sampling and timing of insecticide application to economically control the cotton fleahopper in the Texas Blacklands was developed. TEXCIM, a computer decision aid for pest management was used to evaluate the economics of early season insect control. TEXCIM was also used to place a dollar value on fruit and fruit loss throughout the production season. A panel discussion at the annual Texas Cotton Insect Research Review and Guide Revision Conference was devoted to managing cotton for earliness with an emphasis on early season insect management. Research scientists and extension specialists stressed the value of managing for earliness using a multi-tactic, IPM approach. This approach is nothing new for Texas, as it has been going on for the last several years.

Monitoring and management of pyrethroid-resistant TBW was much more extensive in 1987. The Plapp adult vial technique was used to field assay the TBW for resistance throughout the major cotton production regions of Texas and Oklahoma. Monitoring was coordinated with efforts in Louisiana, Mississippi, and Arkansas.

A model that predicts emergence of the boll weevil from diapause for the Rolling Plains production regions was developed and was very accurate at predicting 50% emergence. Research continues to predict survivorship of boll weevil under varying environmental conditions. Similarly, a heat driven model that accurately predicts 50% emergence of the BW from diapause for the High Plains regions was developed. The MOTH-ZV *Heliothis* simulation model was used to increase insecticide timing and efficiency for BW control in the High Plains.

COTFLEX, an expert system for cotton production, continues to move toward field implementation. Components dealing with insect management, crop-mix analysis, crop insurance selection, farm policy interpretation, and possibly marketing advice will be ready for field evaluation in 1988. The prototype system is being developed for the Blacklands production area. Training of extension personnel is underway for the implementation of the pest management computer decision aid, TEXCIM.

Texas research and extension priorities for 1988 are: (1) expand and refine TBW resistance monitoring and continue to investigate the most effective insecticides, insecticide combinations and application rates for control of resistant TBW; (2) determine economic threshold and most effective controls for spider mites and aphids in cotton; and (3) determine economic importance of early square shed, separating insect induced and physiologically induced shed. (Texas A&M University).

Females of the tachinid *Eucelatoria bryani* were found to respond positively to pigeon pea, corn silk, velvetleaf, tomato, sorghum, and okra in an olfactometer. They did not respond positively to cotton or Mexican spur. These data indicate the importance of plant produced synomones in the habitat location behavior of this parasitoid. Cotton with feeding BW larvae elicited a positive response from female flies, indicating that host-produced kairomones are involved in host location at least over short distances.

Extracts from BW larval cuticles were shown to contain chemicals that stimulate larviposition by *E. bryani*. How these different chemicals interact in nature has not been determined.

The cost of the artificial diet for the tachinid *E. bryani* was lowered by reducing the concentration of several expensive ingredients. The addition of relatively inexpensive material to the artificial diet overcame much of the reason for using *Heliothis* larvae for the first 24 h before the *E. bryani* maggots are transferred to artificial diet. A concentration of 1.5% agar still was the optimal concentration for rearing *Eucelatoria bryani* on artificial diets. Data confirm that the tachinids *Archytas marmoratus* and *Palexorista laxa* are more difficult to rear on artificial diets than are *Eucelatoria*. However, an inexpensive addition to the diet is a very promising replacement for agar in the artificial diet for *Palexorista* because of the advantages provided by this parasitoid's morphology. This suggests that certain species of tachinids are promising candidates for *in vitro* production.

Paper capsules for field release of *Trichogramma* were tested and proved effective. They were, however, subject to intrusion by fire ants. Treatment of the capsules with either 5% ethyl phthalate or 10% N, N-Diethyl-m-Toluamide inhibited attack by the ants but also had a moderately negative effect on parasitoid emergence.

A small modification resulted in significantly increased yields of *Trichogramma* adults reared on artificial diets containing insect hemolymph. This change is expected to produce increased yields when it is applied to future artificial diets devoid of expensive insect components. Before this discovery, the only means of obtaining significant yields *in vitro* of *Trichogramma* adults was by adding highly expensive host egg factors. An ovipositional stimulant for a *Trichogramma* species has been identified.

Evaluations of slow release pheromone dispensers for BW and TBW moths indicated that: (1) commercial black-molded PVC dispensers for TBW available from Scentry, Inc. Buckeye, AZ, were at least as effective as similar type dispensers prepared by D. E. Hendricks, ARS, Weslaco, TX; (2) rubber septa

dispensers containing 1 mg of a 97:3 ratio of Z-11-hexadecenal:Z-9-hexadecenal for BW initially were as effective as Hercon laminated dispensers, but efficacy declined after several days and remained relatively consistent but significantly less than the laminate; (3) unaged and aged (8 days) 1 and 10 mg rubber septa dispensers for BW containing the above blend were compared and the unaged 1 mg rubber septa dispensers were significantly better than the unaged 10 mg or aged 1 or 10 mg dispensers; (4) dosages of 0.625 and 1.25 mg in the Hercon laminate for the BW were more effective than 2.5 or 5.0 mg dosages indicating that the amount of pheromone in the slow release dispensers is critical; and (5) addition of 0.25 or 1% of Z-11-hexadecen-1-ol to a binary or 6 component blend in molded black PVC dispensers for TBW significantly increased captures compared to dispensers without the alcohol; however 5.95% of the alcohol significantly decreased captures.

As part of a three location, three year ARS pilot test on calibration of sex pheromone traps for monitoring BW and TBW field populations, four traps for each species were operated; one on each side of ca. five 8-9 ha cotton fields in the Brazos River Valley. Fields were sampled for Heliothis eggs, larvae, and adults. Species composition of captures in the pheromone traps reflected the species composition of eggs in the field; however, the correlation between the number of males captured in pheromone traps was higher for TBW than the BW. The dispersal of laboratory-reared and field populations was studied by marking the insect with cesium or rubidium, respectively, and monitoring the occurrence of marked eggs or males radiating out from a central area. Dispersal of up to three miles was detected in laboratory-reared TBW males, but their behavior was not very natural. Large numbers of marked BW moths emerged from a corn plot and less moths emerged from a sorghum plot.

A large, helicopter-towed net (7 x 7 ft.) was developed with the capability of sampling ca. 300,000 $M^3$ of air/hour at a speed of ca. 40 mph. Preliminary evaluations show the capability to collect different species of airborne insects. Few moths have been captured, but airborne insect densities have been relatively low during most sampling flights. (USDA, College Station).

Tennessee. Two cultivars, McNair 220 and Stoneville 506, were compared for yield and maturity in a simulated BW threshold study where 0, 5, 10, and

20% of the squares were removed weekly from the plot. For the season, Stoneville 506 produced significantly more bolls than McNair 220. No significant total boll differences were found among the treatments. Total lint was not significantly different among treatments or between cultivars. At first harvest, 32 and 22% of the total seed cotton was picked from McNair 220 and Stoneville 506, respectively. McNair 220 produced significantly more bolls, seed cotton, and lint than Stoneville 506. Among the treatments, no significant boll number differences were noted, but all were significantly lower than the untreated check (0% removed). Seed cotton and lint weight were not significantly different among the 5, 10, 20% removal treatments. Seed cotton and lint weight from 0 and 5% removal were not different from each other. When the first two harvests were combined, approximately 90% of the cotton was harvested. Treatments were highly significant for total bolls, but not for total lint. Cultivar effects were not significant for total bolls or lint. The 5, 10, and 20% treatments were not different from each other for total bolls; 0 and 5% were not different from each other. A preliminary analysis of the data seems to indicate that neither cultivar will suffer significant yield losses when 5% of the squares are removed. (University of Tennessee).

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Table 1. 1987 US Cotton Crop Production. (Source: USDA Crop Reporting Service).

| --Upland-- | Acres Harvested[a] | Indicated Yield[b] | --Production-- Jan 1[c] | 1986[c] |
|---|---|---|---|---|
| ALA | 333 | 588 | 408 | 330 |
| AZ | 299 | 1,365 | 850 | 675 |
| ARK | 570 | 762 | 905 | 602 |
| CALIF | 1,120 | 1,264 | 2,950 | 2,245 |
| GA | 245 | 666 | 340 | 185 |
| LA | 600 | 792 | 990 | 673 |
| MISS | 1,010 | 832 | 1,750 | 1,190 |
| MO | 189 | 830 | 327 | 196 |
| NM | 62 | 735 | 95 | 62 |
| NC | 95 | 505 | 100 | 109 |
| OKLA | 400 | 420 | 350 | 210 |
| SC | 119 | 444 | 110 | 87 |
| TENN | 445 | 701 | 650 | 396 |
| TEXAS | 4,400 | 502 | 4,600 | 2,535 |
| US | 9,915 | 700 | 14,460 | 9,525 |
| --PIMA-- | | | | |
| US | 135 | 941 | 264 | 206 |
| --ALL COTTON-- | | | | |
| US | 10,049 | 703 | 14,724 | 9,731 |

a/ Acres in thousands
b/ Yield in lbs/acre
c/ Production in thousand 480 lb bales

Table 2. Estimated damage to cotton in the USA by arthropod pests with consequent cost of control and yield loss. (Prepared January 14, 1988).

Table 2a. All States

| Pest | Acres infested | Above treatment thresholds | No. appli-cations | Cost per appli-cation | % Yield reduction | Bales lost |
|---|---|---|---|---|---|---|
| Boll weevils | 5141615 | 3758401 | 2.6 | 3.70 | 2.24 | 325403 |
| Boll/budworms | 8506099 | 5617023 | 1.9 | 7.02 | 1.97 | 286796 |
| Fleahoppers | 6888887 | 3179216 | 0.4 | 2.67 | 0.92 | 133561 |
| Lygus bugs | 3780513 | 1608053 | 0.2 | 3.87 | 0.25 | 37445 |
| Leaf perforator | 202800 | 120000 | 0.0 | 9.00 | 0.00 | 682 |
| Pink bollworm | 586000 | 325800 | 0.1 | 8.92 | 0.13 | 19035 |
| Spider mites | 1578457 | 739157 | 0.1 | 10.56 | 0.05 | 7622 |
| Thrips | 6424455 | 3200511 | 0.4 | 3.94 | 0.12 | 18260 |
| Armyworms | 590130 | 275000 | 0.0 | 12.74 | 0.02 | 3849 |
| Minor pests | 3308488 | 1646278 | 0.2 | 4.70 | 0.15 | 22401 |
| New pests | 1046598 | 91076 | 0.0 | 4.50 | 0.00 | 948 |

Acreage harvested: 9914110 Yield per acre: 1.46 Bales
Percent lost: 5.89 Dollars lost: 246,530,321 Cost per acre: 31.89

Table 2b. North Alabama

| Pest | Acres infested | Above treatment thresholds | No. appli-cations | Cost per appli-cation | % Yield reduction | Bales lost |
|---|---|---|---|---|---|---|
| Boll weevils | 200000 | 200000 | 7.7 | 1.95 | 8.50 | 18239 |
| Boll/budworms | 200000 | 200000 | 5.0 | 5.25 | 4.80 | 10300 |
| Fleahoppers | 10000 | 0 | 0.0 | *.** | 0.00 | 0 |
| Lygus bugs | 200000 | 20000 | 0.0 | 0.00 | 0.10 | 214 |
| Leaf perforator | 0 | 0 | 0.0 | 0.00 | 0.00 | 0 |
| Pink bollworm | 0 | 0 | 0.0 | 0.00 | 0.00 | 0 |
| Spider mites | 90000 | 30000 | 0.0 | 1.90 | 0.15 | 321 |
| Thrips | 200000 | 2000 | 0.0 | 8.65 | 0.00 | 10 |
| Armyworms | 15000 | 0 | 0.0 | *.** | 0.00 | 0 |
| Minor pests | 200000 | 150000 | 1.6 | 1.85 | 1.50 | 3218 |
| New pests | 200000 | 10000 | 0.0 | 2.15 | 0.05 | 107 |

Acreage harvested: 200000 Yield per acre: 1.07 Bales
Percent lost: 15.10 Dollars lost: 9,334,890 Cost per acre: 44.47

Table 2c. Central & South Alabama

| Pest | Acres infested | Above treatment thresholds | No. appli- cations | Cost per appli- cation | % Yield reduction | Bales lost |
|---|---|---|---|---|---|---|
| Boll weevils | 152000 | 152000 | 7.3 | 2.10 | 8.38 | 12793 |
| Boll/budworms | 152000 | 152000 | 4.7 | 4.80 | 3.98 | 6076 |
| Fleahoppers | 8000 | 0 | 0.0 | *.** | 0.00 | 0 |
| Lygus bugs | 152000 | 10000 | 0.0 | *.** | 0.00 | 5 |
| Leaf perforator | 0 | 0 | 0.0 | 0.00 | 0.00 | 0 |
| Pink bollworm | 0 | 0 | 0.0 | 0.00 | 0.00 | 0 |
| Spider mites | 15000 | 10000 | 0.0 | 6.00 | 0.00 | 10 |
| Thrips | 152000 | 110000 | 0.7 | 6.75 | 0.22 | 347 |
| Armyworms | 110000 | 10000 | 0.0 | 7.00 | 0.00 | 5 |
| Minor pests | 152000 | 120000 | 1.6 | 1.80 | 1.65 | 2525 |
| New pests | 152000 | 20000 | 0.0 | 3.50 | 0.01 | 21 |

Acreage harvested: 145000 Yield per acre: 1.05 Bales
Percent lost: 14.28 Dollars lost: 6,273,918 Cost per acre: 46.91

Table 2d. Arkansas

| Pest | Acres infested | Above treatment thresholds | No. appli- cations | Cost per appli- cation | % Yield reduction | Bales lost |
|---|---|---|---|---|---|---|
| Boll weevils | 600000 | 550000 | 7.1 | 4.58 | 4.82 | 43656 |
| Boll/budworms | 600000 | 300000 | 1.3 | 6.15 | 1.05 | 9525 |
| Fleahoppers | 600000 | 400 | 0.0 | 3.50 | 0.00 | 0 |
| Lygus bugs | 600000 | 120000 | 0.2 | 3.50 | 0.10 | 952 |
| Leaf perforator | 0 | 0 | 0.0 | 0.00 | 0.00 | 0 |
| Pink bollworm | 0 | 0 | 0.0 | 0.00 | 0.00 | 0 |
| Spider mites | 30000 | 3500 | 0.0 | 4.00 | 0.00 | 0 |
| Thrips | 600000 | 525000 | 0.9 | 5.80 | 0.00 | 0 |
| Armyworms | 0 | 0 | 0.0 | 0.00 | 0.00 | 0 |
| Minor pests | 600000 | 250000 | 0.4 | 2.00 | 0.02 | 198 |
| New pests | 300000 | 1000 | 0.0 | 0.75 | 0.00 | 0 |

Acreage harvested: 570000 Yield per acre: 1.59 Bales
Percent lost: 6.00 Dollars lost: 15,647,670 Cost per acre: 48.10

Table 2e. Arizona

| Pest | Acres infested | Above treatment thresholds | No. appli- cations | Cost per appli- cation | % Yield reduction | Bales lost |
|---|---|---|---|---|---|---|
| Boll weevils | 100000 | 50000 | 1.3 | 9.00 | 0.08 | 710 |
| Boll/budworms | 220000 | 80000 | 0.5 | 10.00 | 0.21 | 1820 |
| Fleahoppers | 60000 | 10000 | 0.0 | 9.00 | 0.00 | 2 |
| Lygus bugs | 260000 | 190000 | 1.2 | 9.00 | 0.63 | 5403 |
| Leaf perforator | 200000 | 120000 | 0.8 | 9.00 | 0.08 | 682 |
| Pink bollworm | 300000 | 290000 | 5.8 | 9.00 | 2.13 | 18143 |
| Spider mites | 200000 | 120000 | 0.8 | 12.00 | 0.16 | 1365 |
| Thrips | 300000 | 20000 | 0.0 | 7.00 | 0.00 | 5 |
| Armyworms | 90000 | 60000 | 0.4 | 9.00 | 0.04 | 341 |
| Minor pests | 180000 | 150000 | 2.0 | 9.00 | 0.05 | 426 |
| New pests | 0 | 0 | 0.0 | 0.00 | 0.00 | 0 |

Acreage harvested: 299000 Yield per acre: 2.84 Bales
Percent lost: 3.39 Dollars lost: 8,323,497 Cost per acre: 120.50

Table 2f. California

| Pest | Acres infested | Above treatment thresholds | No. appli- cations | Cost per appli- cation | % Yield reduction | Bales lost |
|---|---|---|---|---|---|---|
| Boll weevils | 0 | 0 | 0.0 | 0.00 | 0.00 | 0 |
| Boll/budworms | 0 | 0 | 0.0 | 0.00 | 0.00 | 0 |
| Fleahoppers | 0 | 0 | 0.0 | 0.00 | 0.00 | 0 |
| Lygus bugs | 56500 | 45200 | 0.0 | 20.00 | 0.00 | 0 |
| Leaf perforator | 0 | 0 | 0.0 | 0.00 | 0.00 | 0 |
| Pink bollworm | 113000 | 11300 | 0.0 | 16.00 | 0.01 | 297 |
| Spider mites | 290000 | 169500 | 0.2 | 16.00 | 0.00 | 223 |
| Thrips | 0 | 0 | 0.0 | 0.00 | 0.00 | 0 |
| Armyworms | 113000 | 113000 | 0.1 | 20.00 | 0.10 | 2975 |
| Minor pests | 339000 | 113000 | 0.1 | 12.00 | 0.20 | 5951 |
| New pests | 0 | 0 | 0.0 | 0.00 | 0.00 | 0 |

Acreage harvested: 112000 Yield per acre: 2.63 Bales
Percent lost: 0.32 Dollars lost: 2,720,949 Cost per acre: 9.44

Table 2g. Florida

| Pest | Acres infested | Above treatment thresholds | No. appli-cations | Cost per appli-cation | % Yield reduction | Bales lost |
|---|---|---|---|---|---|---|
| Boll weevils | 25310 | 25050 | 4.0 | 5.00 | 7.12 | 2761 |
| Boll/budworms | 25310 | 25310 | 7.1 | 8.70 | 7.20 | 2790 |
| Fleahoppers | 3030 | 0 | 0.0 | *.** | 0.00 | 0 |
| Lygus bugs | 13920 | 3800 | 0.0 | 7.75 | 0.01 | 5 |
| Leaf perforator | 0 | 0 | 0.0 | 0.00 | 0.00 | 0 |
| Pink bollworm | 0 | 0 | 0.0 | 0.00 | 0.00 | 0 |
| Spider mites | 6580 | 1010 | 0.0 | 7.50 | 0.00 | 3 |
| Thrips | 20259 | 2530 | 0.0 | 8.50 | 0.05 | 23 |
| Armyworms | 17700 | 2530 | 0.0 | 8.60 | 0.02 | 11 |
| Minor pests | 21513 | 3040 | 0.0 | 7.70 | 0.03 | 13 |
| New pests | 0 | 0 | 0.0 | 0.00 | 0.00 | 0 |

Acreage harvested: 25310 Yield per acre: 1.39 Bales
Percent lost: 14.47 Dollars lost: 1,615,660 Cost per acre: 82.98

Table 2h. Georgia

| Pest | Acres infested | Above treatment thresholds | No. appli-cations | Cost per appli-cation | % Yield reduction | Bales lost |
|---|---|---|---|---|---|---|
| Boll weevils | 255000 | 255000 | 16.6 | 3.75 | 6.76 | 22997 |
| Boll/budworms | 255000 | 255000 | 6.2 | 6.75 | 2.08 | 7076 |
| Fleahoppers | 112500 | 25000 | 0.1 | 3.88 | 0.07 | 260 |
| Lygus bugs | 125000 | 55000 | 0.2 | 3.88 | 0.22 | 763 |
| Leaf perforator | 0 | 0 | 0.0 | 0.00 | 0.00 | 0 |
| Pink bollworm | 0 | 0 | 0.0 | 0.00 | 0.00 | 0 |
| Spider mites | 10000 | 10000 | 0.0 | 8.75 | 0.00 | 0 |
| Thrips | 200000 | 170000 | 0.9 | 4.75 | 0.00 | 0 |
| Armyworms | 75000 | 50000 | 0.3 | 7.00 | 0.00 | 0 |
| Minor pests | 5000 | 1500 | 0.0 | 8.75 | 0.00 | 0 |
| New pests | 25000 | 25000 | 0.1 | 4.00 | 0.00 | 0 |

Acreage harvested: 245000 Yield per acre: 13.9 Bales
Percent lost: 9.14 Dollars lost: 8,956,035 Cost per acre: 113.25

Table 2i. Louisiana

| Pest | Acres infested | Above treatment thresholds | No. appli-cations | Cost per appli-cation | % Yield reduction | Bales lost |
|---|---|---|---|---|---|---|
| Boll weevils | 597983 | 585272 | 6.8 | 2.85 | 5.85 | 57941 |
| Boll/budworms | 597983 | 542957 | 4.3 | 6.65 | 2.71 | 26876 |
| Fleahoppers | 463840 | 402776 | 0.4 | 2.05 | 0.20 | 1993 |
| Lygus bugs | 480170 | 348228 | 0.4 | 2.25 | 0.20 | 2011 |
| Leaf perforator | 0 | 0 | 0.0 | 0.00 | 0.00 | 0 |
| Pink bollworm | 0 | 0 | 0.0 | 0.00 | 0.00 | 0 |
| Spider mites | 317536 | 179360 | 0.2 | 5.65 | 0.05 | 591 |
| Thrips | 472700 | 370818 | 0.6 | 2.10 | 0.13 | 1346 |
| Armyworms | 2730 | 1520 | 0.0 | *.** | 0.00 | 0 |
| Minor pests | 475000 | 335907 | 0.6 | 3.14 | 0.33 | 3325 |
| New pests | 120298 | 8676 | 0.0 | 5.70 | 0.01 | 143 |

Acreage harvested: 600000 Yield per acre: 1.65 Bales
Percent lost: 9.51 Dollars lost: 27,138,138 Cost per acre: 54.79

Table 2j. Missouri

| Pest | Acres infested | Above treatment thresholds | No. appli-cations | Cost per appli-cation | % Yield reduction | Bales lost |
|---|---|---|---|---|---|---|
| Boll weevils | 189000 | 18000 | 0.3 | 4.00 | 0.38 | 1245 |
| Boll/budworms | 189000 | 60000 | 0.6 | 7.50 | 1.90 | 6225 |
| Fleahoppers | 5000 | 1000 | 0.0 | 4.25 | 0.01 | 34 |
| Lygus bugs | 189000 | 47250 | 0.3 | 3.75 | 0.75 | 2451 |
| Leaf perforator | 1800 | 0 | 0.0 | *.** | 0.00 | 0 |
| Pink bollworm | 0 | 0 | 0.0 | 0.00 | 0.00 | 0 |
| Spider mites | 3600 | 500 | 0.0 | 5.50 | 0.00 | 0 |
| Thrips | 160650 | 56700 | 0.6 | 4.75 | 0.60 | 1960 |
| Armyworms | 9500 | 0 | 0.0 | *.** | 0.00 | 0 |
| Minor pests | 25000 | 7000 | 0.0 | 4.75 | 0.18 | 605 |
| New pests | 0 | 0 | 0.0 | 0.00 | 0.00 | 0 |

Acreage harvested: 189000 Yield per acre: 1.73 Bales
Percent lost: 3.83 Dollars lost: 3,606,267 Cost per acre: 10.85

Table 2k. Mississippi Delta

| Pest | Acres infested | Above treatment thresholds | No. appli-cations | Cost per appli-cation | % Yield reduction | Bales lost |
|---|---|---|---|---|---|---|
| Boll weevils | 656257 | 606957 | 5.1 | 2.35 | 3.45 | 44885 |
| Boll/budworms | 726157 | 716317 | 4.8 | 5.89 | 4.82 | 62600 |
| Fleahoppers | 241750 | 159940 | 0.4 | 1.96 | 0.24 | 3129 |
| Lygus bugs | 613257 | 517425 | 1.6 | 2.34 | 1.45 | 18872 |
| Leaf perforator | 0 | 0 | 0.0 | 0.00 | 0.00 | 0 |
| Pink bollworm | 0 | 0 | 0.0 | 0.00 | 0.00 | 0 |
| Spider mites | 128875 | 88187 | 0.1 | 5.46 | 0.14 | 1859 |
| Thrips | 586257 | 431740 | 0.9 | 2.69 | 0.35 | 4563 |
| Armyworms | 51900 | 19650 | 0.0 | 7.14 | 0.01 | 172 |
| Minor pests | 339775 | 103431 | 0.1 | 6.93 | 0.07 | 950 |
| New pests | 14000 | 10000 | 0.0 | 3.82 | 0.00 | 88 |

Acreage harvested: 742586 Yield per acre: 1.75 Bales
Percent lost: 10.55 Dollars lost: 39,490,926 Cost per acre: 49.95

Table 21. Mississippi Hill

| Pest | Acres infested | Above treatment thresholds | No. appli-cations | Cost per appli-cation | % Yield reduction | Bales lost |
|---|---|---|---|---|---|---|
| Boll weevils | 237908 | 227708 | 8.6 | 2.00 | 7.86 | 20946 |
| Boll/budworms | 227839 | 213139 | 4.2 | 5.21 | 3.72 | 9923 |
| Fleahoppers | 47600 | 14800 | 0.1 | 2.84 | 0.15 | 408 |
| Lygus bugs | 203666 | 136600 | 0.9 | 1.95 | 0.67 | 1799 |
| Leaf perforator | 0 | 0 | 0.0 | 0.00 | 0.00 | 0 |
| Pink bollworm | 0 | 0 | 0.0 | 0.00 | 0.00 | 0 |
| Spider mites | 48066 | 14400 | 0.0 | 4.50 | 0.06 | 164 |
| Thrips | 216539 | 183973 | 1.3 | 1.95 | 0.56 | 1504 |
| Armyworms | 6500 | 500 | 0.0 | 6.50 | 0.00 | 3 |
| Minor pests | 19000 | 2200 | 0.0 | 1.63 | 0.00 | 5 |
| New pests | 4300 | 3400 | 0.0 | 4.81 | 0.09 | 263 |

Acreage harvested: 230655 Yield per acre: 1.16 Bales
Percent lost: 13.14 Dollars lost: 10,085,437 Cost per acre: 45.06

Table 2m. North Carolina

| Pest | Acres infested | Above treatment thresholds | No. appli-cations | Cost per appli-cation | % Yield reduction | Bales lost |
|---|---|---|---|---|---|---|
| Boll weevils | 0 | 0 | 0.0 | 0.00 | 0.00 | 0 |
| Boll/budworms | 87000 | 87000 | 2.7 | 7.00 | 0.91 | 915 |
| Fleahoppers | 0 | 0 | 0.0 | 0.00 | 0.00 | 0 |
| Lygus bugs | 0 | 0 | 0.0 | 0.00 | 0.00 | 0 |
| Leaf perforator | 0 | 0 | 0.0 | 0.00 | 0.00 | 0 |
| Pink bollworm | 0 | 0 | 0.0 | 0.00 | 0.00 | 0 |
| Spider mites | 500 | 100 | 0.0 | 6.80 | 0.00 | 0 |
| Thrips | 87000 | 87000 | 0.9 | 6.00 | 0.27 | 274 |
| Armyworms | 0 | 0 | 0.0 | 0.00 | 0.00 | 0 |
| Minor pests | 15000 | 5000 | 0.0 | 7.00 | 0.00 | 0 |
| New pests | 70000 | 3000 | 0.0 | 5.50 | 0.03 | 37 |

Acreage harvested: 95000 Yield per acre: 1.05 Bales
Percent lost: 1.22 Dollars lost: 353,755 Cost per acre: 25.45

Table 2n. New Mexico

| Pest | Acres infested | Above treatment thresholds | No. appli-cations | Cost per appli-cation | % Yield reduction | Bales lost |
|---|---|---|---|---|---|---|
| Boll weevils | 0 | 0 | 0.0 | 0.00 | 0.00 | 0 |
| Boll/budworms | 22710 | 5200 | 0.0 | 8.00 | 0.41 | 398 |
| Fleahoppers | 33250 | 7000 | 0.1 | 9.00 | 0.56 | 535 |
| Lygus bugs | 39000 | 8550 | 0.0 | 8.00 | 0.68 | 654 |
| Leaf perforator | 1000 | 0 | 0.0 | *.** | 0.00 | 0 |
| Pink bollworm | 23000 | 4500 | 0.1 | 9.00 | 0.36 | 344 |
| Spider mites | 12700 | 1000 | 0.0 | 8.00 | 0.01 | 15 |
| Thrips | 44200 | 9100 | 0.1 | 7.00 | 0.73 | 696 |
| Armyworms | 13600 | 1500 | 0.0 | 8.00 | 0.12 | 114 |
| Minor pests | 200 | 200 | 0.0 | 4.00 | 0.00 | 3 |
| New pests | 0 | 0 | 0.0 | 0.00 | 0.00 | 0 |

Acreage harvested: 62000 Yield per acre: 1.53 Bales
Percent lost: 2.91 Dollars lost: 795,784 Cost per acre: 4.74

Table 2o. Oklahoma

| Pest | Acres infested | Above treatment thresholds | No. appli-cations | Cost per appli-cation | % Yield reduction | Bales lost |
|---|---|---|---|---|---|---|
| Boll weevils | 115000 | 95000 | 0.7 | 4.75 | 1.18 | 4156 |
| Boll/budworms | 375000 | 150000 | 1.1 | 10.50 | 1.87 | 6562 |
| Fleahoppers | 375000 | 100000 | 0.0 | 4.75 | 0.22 | 787 |
| Lygus bugs | 0 | 0 | 0.2 | 0.00 | 0.00 | 0 |
| Leaf perforator | 0 | 0 | 0.0 | 0.00 | 0.00 | 0 |
| Pink bollworm | 0 | 0 | 0.0 | 0.00 | 0.00 | 0 |
| Spider mites | 35000 | 15000 | 0.0 | 8.75 | 0.01 | 65 |
| Thrips | 375000 | 5000 | 0.0 | 4.75 | 0.00 | 0 |
| Armyworms | 0 | 0 | 0.0 | 0.00 | 0.00 | 0 |
| Minor pests | 0 | 0 | 0.0 | 0.00 | 0.00 | 0 |
| New pests | 0 | 0 | 0.0 | 0.00 | 0.00 | 0 |

Acreage harvested: 400000 Yield per acre: 0.88 Bales
Percent lost: 3.30 Dollars lost: 3,332,826 Cost per acre: 17.10

Table 2p. South Carolina

| Pest | Acres infested | Above treatment thresholds | No. appli-cations | Cost per appli-cation | % Yield reduction | Bales lost |
|---|---|---|---|---|---|---|
| Boll weevils | 40000 | 50 | 0.0 | 3.00 | 0.00 | 0 |
| Boll/budworms | 122000 | 85000 | 2.8 | 6.75 | 2.14 | 2358 |
| Fleahoppers | 35000 | 400 | 0.0 | 4.00 | 0.00 | 0 |
| Lygus bugs | 45000 | 2000 | 0.0 | 4.00 | 0.00 | 0 |
| Leaf perforator | 0 | 0 | 0.0 | 0.00 | 0.00 | 0 |
| Pink bollworm | 0 | 0 | 0.0 | 0.00 | 0.00 | 0 |
| Spider mites | 2000 | 500 | 0.0 | 8.00 | 0.00 | 0 |
| Thrips | 115000 | 50000 | 0.6 | 3.00 | 0.04 | 46 |
| Armyworms | 15000 | 1000 | 0.0 | 11.00 | 0.01 | 18 |
| Minor pests | 15000 | 15000 | 0.1 | 4.50 | 0.00 | 0 |
| New pests | 25000 | 5000 | 0.0 | 4.50 | 0.21 | 231 |

Acreage harvested: 119000 Yield per acre: 0.93 Bales
Percent lost: 2.41 Dollars lost: 764,701 Cost per acre: 22.74

Table 2q. Tennessee

| Pest | Acres infested | Above treatment thresholds | No. appli-cations | Cost per appli-cation | % Yield reduction | Bales lost |
|---|---|---|---|---|---|---|
| Boll weevils | 103640 | 35998 | 0.4 | 4.00 | 0.16 | 1051 |
| Boll/budworms | 296250 | 118500 | 0.5 | 7.00 | 2.13 | 13844 |
| Fleahoppers | 0 | 0 | 0.0 | 0.00 | 0.00 | 0 |
| Lygus bugs | 300000 | 50000 | 0.1 | 3.00 | 0.11 | 730 |
| Leaf perforator | 0 | 0 | 0.0 | 0.00 | 0.00 | 0 |
| Pink bollworm | 0 | 0 | 0.0 | 0.00 | 0.00 | 0 |
| Spider mites | 100000 | 5000 | 0.0 | 4.00 | 0.00 | 0 |
| Thrips | 300000 | 75000 | 0.1 | 2.50 | 0.00 | 54 |
| Armyworms | 50000 | 100 | 0.0 | 4.00 | 0.00 | 0 |
| Minor pests | 100000 | 10000 | 0.0 | 3.00 | 0.02 | 146 |
| New pests | 0 | 0 | 0.0 | 0.00 | 0.00 | 0 |

Acreage harvested: 445000 Yield per acre: 1.46 Bales
Percent lost: 2.43 Dollars lost: 4,558,450 Cost per acre: 6.54

Table 2r. Texas Area I

| Pest | Acres infested | Above treatment thresholds | No. appli-cations | Cost per appli-cation | % Yield reduction | Bales lost |
|---|---|---|---|---|---|---|
| Boll weevils | 40000 | 10000 | 0.1 | 5.10 | 0.12 | 62 |
| Boll/budworms | 50000 | 8000 | 0.1 | 9.50 | 0.10 | 50 |
| Fleahoppers | 55000 | 13000 | 0.0 | 4.50 | 0.16 | 81 |
| Lygus bugs | 0 | 0 | 0.0 | 0.00 | 0.00 | 0 |
| Leaf perforator | 0 | 0 | 0.0 | 0.00 | 0.00 | 0 |
| Pink bollworm | 0 | 0 | 0.0 | 0.00 | 0.00 | 0 |
| Spider mites | 0 | 0 | 0.0 | 0.00 | 0.00 | 0 |
| Thrips | 80000 | 40000 | 0.5 | 4.00 | 0.25 | 125 |
| Armyworms | 0 | 0 | 0.0 | 0.00 | 0.00 | 0 |
| Minor pests | 0 | 0 | 0.0 | 0.00 | 0.00 | 0 |
| New pests | 0 | 0 | 0.0 | 0.00 | 0.00 | 0 |

Acreage harvested: 80000 Yield per acre: 0.62 Bales
Percent lost: 0.63 Dollars lost: 91,800 Cost per acre: 4.27

Table 2s. Texas Area II

| Pest | Acres infested | Above treatment thresholds | No. appli-cations | Cost per appli-cation | % Yield reduction | Bales lost |
|---|---|---|---|---|---|---|
| Boll weevils | 130000 | 15000 | 0.0 | 5.50 | 0.00 | 7 |
| Boll/budworms | 2120000 | 1378000 | 0.6 | 9.75 | 1.62 | 44785 |
| Fleahoppers | 2650000 | 1192500 | 0.5 | 2.75 | 3.60 | 99375 |
| Lygus bugs | 40000 | 40000 | 0.0 | 5.00 | 0.00 | 62 |
| Leaf perforator | 0 | 0 | 0.0 | 0.00 | 0.00 | 0 |
| Pink bollworm | 0 | 0 | 0.0 | 0.00 | 0.00 | 0 |
| Spider mites | 80000 | 10000 | 0.0 | 15.00 | 0.00 | 1 |
| Thrips | 1750000 | 850000 | 0.3 | 4.4 | 0.17 | 4692 |
| Armyworms | 0 | 0 | 0.0 | 0.0 | 0.00 | 0 |
| Minor pests | 172000 | 60000 | 0.0 | 4.0 | 0.00 | 212 |
| New pests | 0 | 0 | 0.0 | 0.00 | 0.00 | 0 |

Acreage harvested: 2650000 Yield per acre: 1.04 Bales
Percent lost: 5.40 Dollars lost: 42,951,330 Cost per acre: 10.18

Table 2t. Texas Area III

| Pest | Acres infested | Above treatment thresholds | No. appli-cations | Cost per appli-cation | % Yield reduction | Bales lost |
|---|---|---|---|---|---|---|
| Boll weevils | 700000 | 250000 | 1.1 | 5.10 | 2.93 | 18604 |
| Boll/budworms | 800000 | 180000 | 0.3 | 9.50 | 0.67 | 4275 |
| Fleahoppers | 750000 | 300000 | 0.3 | 2.50 | 0.11 | 712 |
| Lygus bugs | 0 | 0 | 0.0 | 0.00 | 0.00 | 0 |
| Leaf perforator | 0 | 0 | 0.0 | 0.00 | 0.00 | 0 |
| Pink bollworm | 0 | 0 | 0.0 | 0.00 | 0.00 | 0 |
| Spider mites | 15000 | 7000 | 0.0 | 12.00 | 0.00 | 55 |
| Thrips | 10000 | 5000 | 0.0 | 1.85 | 0.00 | 0 |
| Armyworms | 0 | 0 | 0.0 | 0.00 | 0.00 | 0 |
| Minor pests | 0 | 0 | 0.0 | 0.00 | 0.00 | 0 |
| New pests | 0 | 0 | 0.0 | 0.00 | 0.00 | 0 |

Acreage harvested: 800000 Yield per acre: 0.79 Bales
Percent lost: 3.73 Dollars lost: 6,810,360 Cost per acre: 10.17

Table 2u. Texas Area IV

| Pest | Acres infested | Above treatment thresholds | No. appli-cations | Cost per appli-cation | % Yield reduction | Bales lost |
|---|---|---|---|---|---|---|
| Boll weevils | 15000 | 5000 | 0.0 | 4.25 | 0.00 | 2 |
| Boll/budworms | 75000 | 20000 | 0.5 | 8.00 | 0.43 | 291 |
| Fleahoppers | 75000 | 30000 | 0.3 | 4.50 | 0.00 | 5 |
| Lygus bugs | 5000 | 1000 | 0.0 | 5.50 | 0.00 | 0 |
| Leaf perforator | 0 | 0 | 0.0 | 0.00 | 0.00 | 0 |
| Pink bollworm | 0 | 0 | 0.0 | 0.00 | 0.00 | 0 |
| Spider mites | 8000 | 500 | 0.0 | 8.00 | 0.00 | 0 |
| Thrips | 70000 | 50000 | 1.2 | 3.50 | 0.12 | 83 |
| Armyworms | 0 | 0 | 0.0 | 0.00 | 0.00 | 0 |
| Minor pests | 0 | 0 | 0.0 | 0.00 | 0.00 | 0 |
| New pests | 0 | 0 | 0.0 | 0.00 | 0.00 | 0 |

Acreage harvested: 80000 Yield per acre: 0.83 Bales
Percent lost: 0.57 Dollars lost: 110,076 Cost per acre: 10.44

Table 2v Texas Area V & IX

| Pest | Acres infested | Above treatment thresholds | No. appli-cations | Cost per appli-cation | % Yield reduction | Bales lost |
|---|---|---|---|---|---|---|
| Boll weevils | 20000 | 20000 | 3.1 | 5.00 | 5.26 | 833 |
| Boll/budworms | 20000 | 10000 | 1.5 | 8.00 | 5.26 | 833 |
| Fleahoppers | 20000 | 15000 | 0.7 | 4.00 | 3.94 | 625 |
| Lygus bugs | 0 | 0 | 0.0 | 0.00 | 0.00 | 0 |
| Leaf perforator | 0 | 0 | 0.0 | 0.00 | 0.00 | 0 |
| Pink bollworm | 0 | 0 | 0.0 | 0.00 | 0.00 | 0 |
| Spider mites | 20000 | 1000 | 0.0 | 7.00 | 0.26 | 41 |
| Thrips | 20000 | 5000 | 0.2 | 3.00 | 1.31 | 208 |
| Armyworms | 0 | 0 | 0.0 | 0.00 | 0.00 | 0 |
| Minor pests | 0 | 0 | 0.0 | 0.00 | 0.00 | 0 |
| New pests | 0 | 0 | 0.0 | 0.00 | 0.00 | 0 |

Acreage harvested: 19000 Yield per acre: 0.83 Bales
Percent lost: 16.05 Dollars lost: 732,000 Cost per acre: 32.73

Table 2w Texas Area VI

| Pest | Acres infested | Above treatment thresholds | No. appli- cations | Cost per appli- cation | % Yield reduction | Bales lost |
|---|---|---|---|---|---|---|
| Boll weevils | 60000 | 1500 | 0.0 | 6.00 | 0.00 | 0 |
| Boll/budworms | 400000 | 300000 | 1.5 | 9.00 | 3.75 | 18750 |
| Fleahoppers | 360000 | 300000 | 1.1 | 4.00 | 1.50 | 7500 |
| Lygus bugs | 30000 | 10000 | 0.0 | 5.00 | 0.00 | 6 |
| Leaf perforator | 0 | 0 | 0.0 | 0.00 | 0.00 | 0 |
| Pink bollworm | 150000 | 20000 | 0.1 | 1.50 | 0.05 | 250 |
| Spider mites | 0 | 0 | 0.0 | 0.00 | 0.00 | 0 |
| Thrips | 0 | 0 | 0.0 | 0.00 | 0.00 | 0 |
| Armyworms | 0 | 0 | 0.0 | 0.00 | 0.00 | 0 |
| Minor pests | 400000 | 300000 | 0.9 | 2.00 | 0.75 | 3750 |
| New pests | 136000 | 5000 | 0.0 | 8.00 | 0.00 | 0 |

Acreage harvested: 400000 Yield per acre: 1.25 Bales
Percent lost: 6.05 Dollars lost: 8,713,980 Cost per acre: 20.30

Table 2x Texas Area VII

| Pest | Acres infested | Above treatment thresholds | No. appli- cations | Cost per appli- cation | % Yield reduction | Bales lost |
|---|---|---|---|---|---|---|
| Boll weevils | 250000 | 100000 | 1.4 | 5.50 | 2.80 | 5541 |
| Boll/budworms | 250000 | 150000 | 1.2 | 7.50 | 3.00 | 5937 |
| Fleahoppers | 250000 | 140000 | 1.1 | 1.00 | 2.80 | 5541 |
| Lygus bugs | 0 | 0 | 0.0 | 0.00 | 0.00 | 0 |
| Leaf perforator | 0 | 0 | 0.0 | 0.00 | 0.00 | 0 |
| Pink bollworm | 0 | 0 | 0.0 | 0.00 | 0.00 | 0 |
| Spider mites | 20000 | 20000 | 0.1 | 12.00 | 0.08 | 158 |
| Thrips | 0 | 0 | 0.0 | 0.00 | 0.00 | 0 |
| Armyworms | 0 | 0 | 0.0 | 0.00 | 0.00 | 0 |
| Minor pests | 250000 | 20000 | 0.0 | 1.00 | 0.06 | 126 |
| New pests | 0 | 0 | 0.0 | 0.00 | 0.00 | 0 |

Acreage harvested: 250000 Yield per acre: 0.79 Bales
Percent lost: 8.74 Dollars lost: 4,984,080 Cost per acre: 19.82

Table 2y Texas Area VIII

| Pest | Acres infested | Above treatment thresholds | No. appli-cations | Cost per appli-cation | % Yield reduction | Bales lost |
|---|---|---|---|---|---|---|
| Boll weevils | 25000 | 15000 | 1.5 | 4.00 | 6.02 | 1156 |
| Boll/budworms | 25000 | 15000 | 1.2 | 11.00 | 3.01 | 578 |
| Fleahoppers | 25000 | 25000 | 2.0 | 3.50 | 5.02 | 963 |
| Lygus bugs | 8000 | 2000 | 0.0 | 5.00 | 0.16 | 30 |
| Leaf perforator | 0 | 0 | 0.0 | 0.00 | 0.00 | 0 |
| Pink bollworm | 0 | 0 | 0.0 | 0.00 | 0.00 | 0 |
| Spider mites | 5000 | 1500 | 0.1 | 10.00 | 0.30 | 57 |
| Thrips | 25000 | 25000 | 1.0 | 3.00 | 1.50 | 289 |
| Armyworms | 0 | 0 | 0.0 | 0.00 | 0.00 | 0 |
| Minor pests | 0 | 0 | 0.0 | 0.00 | 0.00 | 0 |
| New pests | 0 | 0 | 0.0 | 0.00 | 0.00 | 0 |

Acreage harvested: 24900 Yield per acre: 0.77 Bales
Percent lost: 16.02 Dollars lost: 885,780 Cost per acre: 30.92

Table 2z Texas Area X

| Pest | Acres infested | Above treatment thresholds | No. appli-cations | Cost per appli-cation | % Yield reduction | Bales lost |
|---|---|---|---|---|---|---|
| Boll weevils | 6100 | 3870 | 0.0 | 4.65 | 0.03 | 74 |
| Boll/budworms | 68000 | 51000 | 1.0 | 9.10 | 0.59 | 1287 |
| Fleahoppers | 87500 | 69000 | 0.4 | 1.35 | 0.04 | 93 |
| Lygus bugs | 0 | 0 | 0.0 | 0.00 | 0.00 | 00 |
| Leaf perforator | 0 | 0 | 0.0 | 0.00 | 0.00 | 0 |
| Pink bollworm | 0 | 0 | 0.0 | 0.00 | 0.00 | 0 |
| Spider mites | 20500 | 9100 | 0.0 | 10.25 | 0.01 | 26 |
| Thrips | 52000 | 12000 | 0.0 | 1.90 | 0.00 | 4 |
| Armyworms | 0 | 0 | 0.0 | 0.00 | 0.00 | 0 |
| Minor pests | 0 | 0 | 0.0 | 0.00 | 0.00 | 0 |
| New pests | 0 | 0 | 0.0 | 0.00 | 0.00 | 0 |

Acreage harvested: 112500 Yield per acre: 1.93 Bales
Percent lost: 0.68 Dollars lost: 427,988 Cost per acre: 10.95

Table 2aa Texas Area XI

| Pest | Acres infested | Above treatment thresholds | No. appli-cations | Cost per appli-cation | % Yield reduction | Bales lost |
|---|---|---|---|---|---|---|
| Boll weevils | 86000 | 8600 | 0.3 | 4.00 | 0.99 | 1046 |
| Boll/budworms | 86000 | 51600 | 1.2 | 4.50 | 2.99 | 3139 |
| Fleahoppers | 86000 | 77400 | 1.8 | 1.10 | 4.49 | 4708 |
| Lygus bugs | 0 | 0 | 0.0 | 0.00 | 0.00 | 0 |
| Leaf perforator | 0 | 0 | 0.0 | 0.00 | 0.00 | 0 |
| Pink bollworm | 0 | 0 | 0.0 | 0.00 | 0.00 | 0 |
| Spider mites | 0 | 0 | 0.0 | 0.00 | 0.00 | 0 |
| Thrips | 86000 | 12900 | 0.2 | 1.90 | 0.00 | 7 |
| Armyworms | 0 | 0 | 0.0 | 0.00 | 0.00 | 0 |
| Minor pests | 0 | 0 | 0.0 | 0.00 | 0.00 | 0 |
| New pests | 0 | 0 | 0.0 | 0.00 | 0.00 | 0 |

Acreage harvested: 86133 Yield per acre: 1.22 Bales
Percent lost: 8.49 Dollars lost: 2,563,684 Cost per acre: 9.19

Table 2bb Texas Area XII

| Pest | Acres infested | Above treatment thresholds | No. appli-cations | Cost per appli-cation | % Yield reduction | Bales lost |
|---|---|---|---|---|---|---|
| Boll weevils | 320000 | 320000 | 7.0 | 6.75 | 10.00 | 40666 |
| Boll/budworms | 325000 | 325000 | 4.0 | 8.50 | 3.04 | 12390 |
| Fleahoppers | 325000 | 100000 | 0.3 | 2.00 | 0.31 | 1270 |
| Lygus bugs | 0 | 0 | 0.0 | 0.00 | 0.00 | 0 |
| Leaf perforator | 0 | 0 | 0.0 | 0.00 | 0.00 | 0 |
| Pink bollworm | 0 | 0 | 0.0 | 0.00 | 0.00 | 0 |
| Spider mites | 75000 | 20000 | 0.0 | 5.50 | 0.06 | 254 |
| Thrips | 325000 | 100000 | 0.3 | 6.50 | 0.31 | 1270 |
| Armyworms | 20000 | 15000 | 0.0 | 9.00 | 0.04 | 190 |
| Minor pests | 0 | 0 | 0.0 | 0.00 | 0.00 | 0 |
| New pests | 0 | 0 | 0.0 | 0.00 | 0.00 | 0 |

Acreage harvested: 320000 Yield per acre: 1.27 Bales
Percent lost: 13.78 Dollars lost: 16,140,600 Cost per acre: 85.79

Table 2cc Texas Area XIII

| Pest | Acres infested | Above treatment thresholds | No. appli-cations | Cost per appli-cation | % Yield reduction | Bales lost |
|---|---|---|---|---|---|---|
| Boll weevils | 37000 | 37000 | 6.6 | 4.75 | 7.11 | 6359 |
| Boll/budworms | 39000 | 37000 | 7.1 | 12.00 | 16.12 | 14414 |
| Fleahoppers | 30000 | 25000 | 0.6 | 4.50 | 1.28 | 1145 |
| Lygus bugs | 0 | 0 | 0.0 | 0.00 | 0.00 | 0 |
| Leaf perforator | 0 | 0 | 0.0 | 0.00 | 0.00 | 0 |
| Pink bollworm | 0 | 0 | 0.0 | 0.00 | 0.00 | 0 |
| Spider mites | 20000 | 20000 | 1.0 | 15.00 | 2.56 | 2291 |
| Thrips | 0 | 0 | 0.0 | 0.00 | 0.00 | 0 |
| Armyworms | 200 | 200 | 0.0 | 7.50 | 0.00 | 3 |
| Minor pests | 0 | 0 | 0.0 | 0.00 | 0.00 | 0 |
| New pests | 0 | 0 | 0.0 | 0.00 | 0.00 | 0 |

Acreage harvested: 39000 Yield per acre: 2.29 Bales
Percent lost: 27.09 Dollars lost: 6,973,956 Cost per acre: 135.27

Table 2dd Texas Area XIV

| Pest | Acres infested | Above treatment thresholds | No. appli-cations | Cost per appli-cation | % Yield reduction | Bales lost |
|---|---|---|---|---|---|---|
| Boll weevils | 180417 | 171396 | 4.2 | 5.00 | 2.84 | 6427 |
| Boll/budworms | 150000 | 100000 | 8.3 | 6.00 | 1.55 | 3500 |
| Fleahoppers | 180417 | 171000 | 1.2 | 3.00 | 1.89 | 4275 |
| Lygus bugs | 60000 | 1000 | 0.0 | 4.00 | 0.00 | 0 |
| Leaf perforator | 0 | 0 | 0.0 | 0.00 | 0.00 | 0 |
| Pink bollworm | 0 | 0 | 0.0 | 0.00 | 0.00 | 0 |
| Spider mites | 25000 | 2000 | 0.0 | 4.00 | 0.00 | 0 |
| Thrips | 175000 | 1750 | 0.0 | 2.50 | 0.00 | 0 |
| Armyworms | 0 | 0 | 0.0 | 0.00 | 0.00 | 0 |
| Minor pests | 0 | 0 | 0.0 | 0.00 | 0.00 | 0 |
| New pests | 0 | 0 | 0.0 | 0.00 | 0.00 | 0 |

Acreage harvested: 180417 Yield per acre: 1.25 Bales
Percent lost: 6.29 Dollars lost: 4,090,276 Cost per acre: 75.04

Table 2ee Virginia

| Pest | Acres infested | Above treatment thresholds | No. appli-cations | Cost per appli-cation | % Yield reduction | Bales lost |
|---|---|---|---|---|---|---|
| Boll weevils | 0 | 0 | 0.0 | 0.00 | 0.00 | 0 |
| Boll/budworms | 1850 | 1000 | 1.0 | 11.00 | 2.43 | 46 |
| Fleahoppers | 0 | 0 | 0.0 | 0.00 | 0.00 | 0 |
| Lygus bugs | 0 | 0 | 0.0 | 0.00 | 0.00 | 0 |
| Leaf perforator | 0 | 0 | 0.0 | 0.00 | 0.00 | 0 |
| Pink bollworm | 0 | 0 | 0.0 | 0.00 | 0.00 | 0 |
| Spider mites | 100 | 0 | 0.0 | *.** | 0.00 | 0 |
| Thrips | 1850 | 0 | 0.0 | *.** | 0.00 | 0 |
| Armyworms | 0 | 0 | 0.0 | 0.00 | 0.00 | 0 |
| Minor pests | 0 | 0 | 0.0 | 0.00 | 0.00 | 0 |
| New pests | 0 | 0 | 0.0 | 0.00 | 0.00 | 0 |

Acreage harvested: 1850 Yield per acre: 1.04 Bales
Percent lost: 2.43 Dollars lost: 13,500 Cost per acre: 11.89

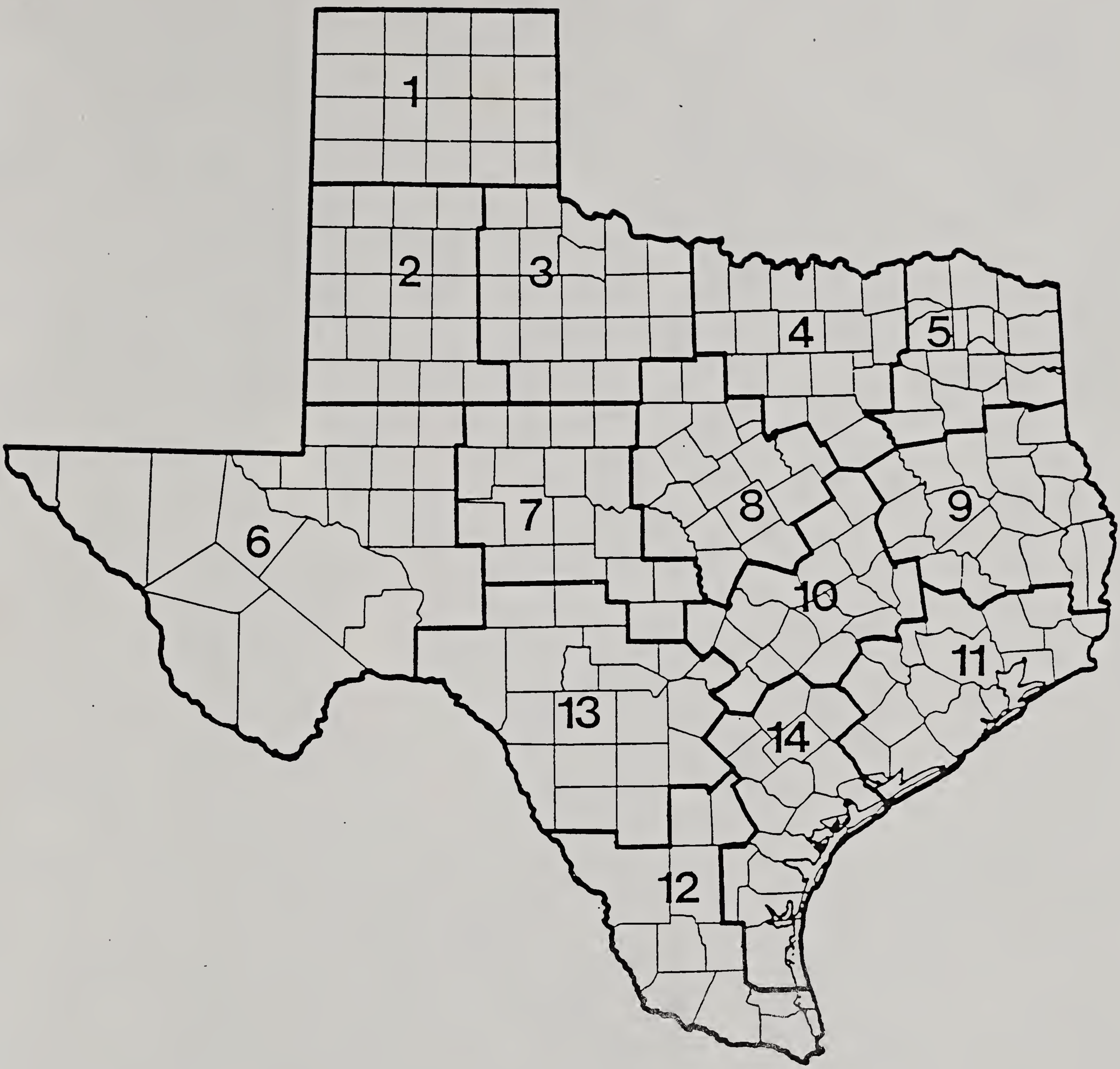


Fig. 1. Areas in Texas relating to Table 2 for estimating the damage to cotton in the USA by arthropod pests with consequent cost of control and yield loss.